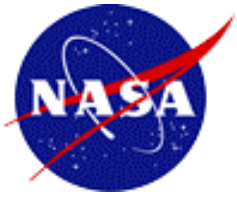
FINAL

PROTECTED SPECIES MANAGEMENT STRATEGY FOR NASA GLENN RESEARCH CENTER AT LEWIS FIELD AND PLUM BROOK STATION

VOLUME II: PLANT COMMUNITY SURVEY

Prepared for:



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April 19, 2002

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ACRONYMS AND ABBREVIATIONS

B&W	Black and White
ESA	Endangered Species Act
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System
GPS	Global Positioning System
GRC	Glenn Research Center
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NWI	National Wetlands Inventory
ODNR	Ohio Department of Natural Resources
PBS	Plum Brook Station
SAIC	Science Applications International Corporation
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USGS	United States Geographic Service

1. INTRODUCTION

This report was prepared by Science Applications International Corporation (SAIC) to assist the National Aeronautics and Space Administration (NASA) in preparing a protected species management strategy. The report presents the results of plant community surveys conducted for NASA's Glenn Research Center (GRC), located at Lewis Field in Cleveland, OH and Plum Brook Station (PBS) near Sandusky, OH. Documentation and mapping of plant communities is an important component to managing protected species. Effective management of protected species is often accomplished through management of the biological community in which the species are a component. Therefore, knowing the types, locations, quantities, and quality of available habitat is crucial to the management of protected species and natural resources, in general.

NASA facilities are required to maintain current records of species protected by the Endangered Species Act (ESA). In addition, NASA facilities must develop programs for the management of any protected species and their critical habitat where present on property managed by NASA. It is the policy of NASA GRC to comply with all applicable federal and state regulations with regards to endangered and threatened species. To facilitate GRC's compliance with the ESA and NASA policies, SAIC proposed a strategy for the identification and management of protected species at the GRC and PBS facilities. The strategy consists of three interrelated tasks:

1) Perform biological surveys at Lewis Field and PBS to provide current records of protected species at these facilities.
2) Develop geographic information system (GIS) data layers identifying the terrestrial plant communities and aquatic habitats at the two facilities and incorporating locations of protected species identified during the surveys.
3) Produce a management plan for the protected species that utilizes the GIS as a management tool.

The goal of this strategy is to produce a management plan that contains current information, is easily updated, and is integrated with other spatial data critical to the management of the facility. The GIS data layers will become a component of the facility GISs developed by the Stennis Space Center.

The three components of the management strategy are presented in three reports, *Protected Species Management Strategy, Volumes I - III*. Volume I: Biological Surveys (ODNR 2002) was prepared by the Ohio Department of Natural Resources under contract to SAIC. Volume I corresponds to component one of the strategy. This report is Volume II: Plant Community Survey and corresponds to component two of the strategy. Volume II is the companion text to the electronic GIS data layers developed for this project. Volume III: Management Plan integrates the results of Volumes I and II to present management strategies for protected species and important plant communities at PBS and Lewis Field.

In order to facilitate the development and implementation of species management plans, a plant community and aquatic resource map was created as a GIS data layer for both the Lewis Field and PBS facilities. The map will provide the "community context" for all protected species observed during biological surveys.

1.1 Project Description for Plant Community Survey

The Plant Community Survey focuses on the development of baseline vegetation maps with community descriptions for PBS and Lewis Field. This map also portrays aquatic resources such as ponds, streams, and wetlands. The map was produced as an ARC/INFO J data layer that will be incorporated into the GIS currently under development for PBS and Lewis Field. This study was completed during the 2001 field season (April thru October). Plant communities and aquatic habitats were identified, mapped, and described by evaluating existing information (aerial photographs, previous reports, and maps) and field surveys at both PBS and Lewis Field. This report (Volume II) summarizes the study and mapping of existing plant communities and aquatic habitats at PBS and Lewis Field. In addition, it accompanies electronic GIS data layers that portray this information in a spatial database. The report will be used as a baseline document in conjunction with other natural resource documents to assist with the development of a protected species management plan for PBS and Lewis Field.

PBS is far larger than Lewis Field and it contains many more rare species and important plant communities. Therefore, investigation and documentation of plant communities at PBS required significantly more effort. The greater importance of natural resources at PBS is reflected in this report by more detailed discussions of areas containing rare species or rare plant communities. In addition, the plant communities at PBS are presented first.

1.2 Site Locations and Descriptions

1.2.1 Lewis Field

Introduction to NASA Lewis Field

The Lewis Field in Cleveland was established in 1941 as the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics (NACA). In 1958, NACA was reorganized into NASA and the laboratory became part of the new organization. On-site technical and support facilities have expanded continuously throughout the years and the campus-like setting now includes a diverse array of laboratories, office buildings, research and test stations, and support facilities.

Size and Location

At its Cleveland site, NASA owns or leases 147.62 hectares (364.49 acres) (LeRC 1995). The site is located in western Cuyahoga County, Ohio and is predominantly within the city limits of Brookpark, approximately twenty miles southwest of downtown. A small part of the site to the north is located in the city of Fairview Park, and a parcel of land to the west is in the city of Brook Park. The site borders the Cleveland Hopkins International Airport to the east. To the north and west is the Rocky River Reservation, a part of the Cleveland Metropolitan Park District (Metroparks). The southern

boundary of the site is adjacent to residential and business districts of the city of Brook Park, including the Tech Park office development.

The site lies between latitudes 41°24' and 41°25'30"N, and longitudes 81°51' and 81°53"W. The location can be found on the United States Geological Survey (USGS) 7.5 minute-series topographic map for the Lakewood Quadrangle (41081-D7-TF-024).

Site Facilities

The Lewis Field site is organized administratively into four geographic areas. The North Area is the land north of Brookpark Road. This contains two administrative buildings and a parking lot. This area is within the city of Fairview Park. The Central Area is the largest portion and contains the greatest concentration of buildings and many of the major test facilities. The Central Area contains specialized facilities that supply altitude exhaust, compressed air, and cooling water. These systems are essential to a number of test operations and therefore combustion-related experiments are normally clustered here. The Central Area is bordered by Brookpark Road to the north, the Airport to the east, and Cedar Point Road to the south.

The South Area contains the Rocket Engine Test Facility, the Central Chemical Storage Facility, bulk storage areas, and other facilities requiring a buffer zone. The South Area is the portion of the site south of Cedar Point Road. The West Area is separated from the Central Area by Abram Creek and includes the Management Conference Building, recreational areas, the day care center, and other facilities.

The 1995 *Real Property Report* (LeRC 1995) lists 176 buildings, structures, and other entities at Lewis Field including many specialized Research and Development (R&D) facilities. Lewis Field boasts many unique test facilities for conducting wind tunnel, aeronautics, propulsion, space power, and advanced research.

1.2.2 Plum Brook Station (PBS)

Introduction to NASA Plum Brook Station

The PBS is operated as a satellite facility (component installation) of the NASA Glenn Research Center. Use of this site by the Federal Government began in 1941 when the U.S. Army established the Plum Brook Ordnance Works for the manufacture of munitions. Munitions production took place from 1941 to 1945, after which buildings and production lines were decontaminated and decommissioned. There were then several changes in ownership and eventual transfer of portions of the site to NACA (later NASA) in 1955.

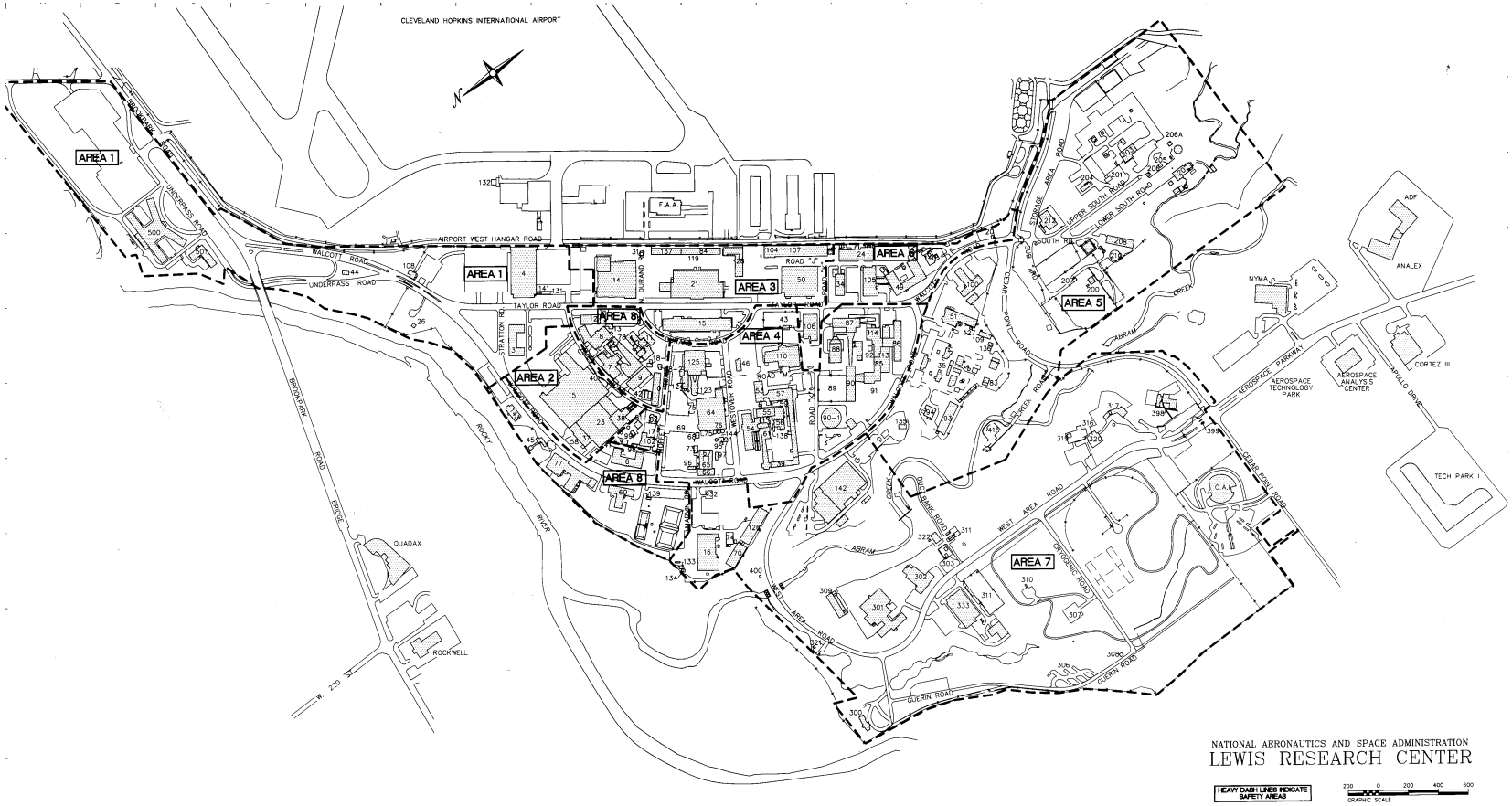

FIGURE 1
MAP OF LEWIS FIELD

NACA's original interest in the site was as a testing location for high-energy rocket engines and nuclear power systems. Other activities at PBS over the years have included the development of special pumps for space applications, rocket engine research, space vehicle testing, cryogenic testing, wind tunnel testing, and related aerospace research.

Size and Location

The NASA portion of the PBS site is 2614 hectares (6454 acres) in size (LeRC 1995). The site is located in a rural area in west central Erie County, Ohio, approximately 80 kilometers (50 miles) west of the Lewis Field facility in Cleveland. The nearest large city is Sandusky, 6 kilometers (4 miles) to the north. Most of the PBS site is in Perkins and Oxford townships, with some land in Huron and Milan townships to the east. The site boundaries are Bogart Road to the north, Mason Road to the south, U.S. Highway 250 to the east, and County Road 43 to the west (Figure 2).

The northernmost point is at latitude 41°23'39"N; and the southernmost point at 41°20'04"N. The westernmost point is at longitude 82°43'12"W; and the easternmost point is at 82°38'39"W. The location can be found on the USGS 7.5 minute-series topographic maps for the Kimball and Sandusky Quadrangles (N4115-W8237.5/7.5 and 41082-D6-TF-024, respectively).

Site Facilities

The 1995 *Real Property Report* (LeRC 1995) lists 179 buildings, structures, and other entities at PBS. These include offices, mechanical and process equipment areas, test facilities, substations, and wastewater treatment facilities.

The PBS was placed on standby status in 1974. Some site facilities were preserved for future use and in 1987 were made available to government and commercial users on a full-cost reimbursable basis. This included four major space-testing facilities.

1.3 Report Organization

The report is organized into eight sections:

Section 1 – Introduction: describes the background and purpose for this project, the location and history of each facility, and the report organization;

Section 2 – Methods and Materials: presents the methodology and relevant materials used to perform the study, including the data sources, field survey techniques, vegetation classification scheme, mapping techniques, and the GIS format;

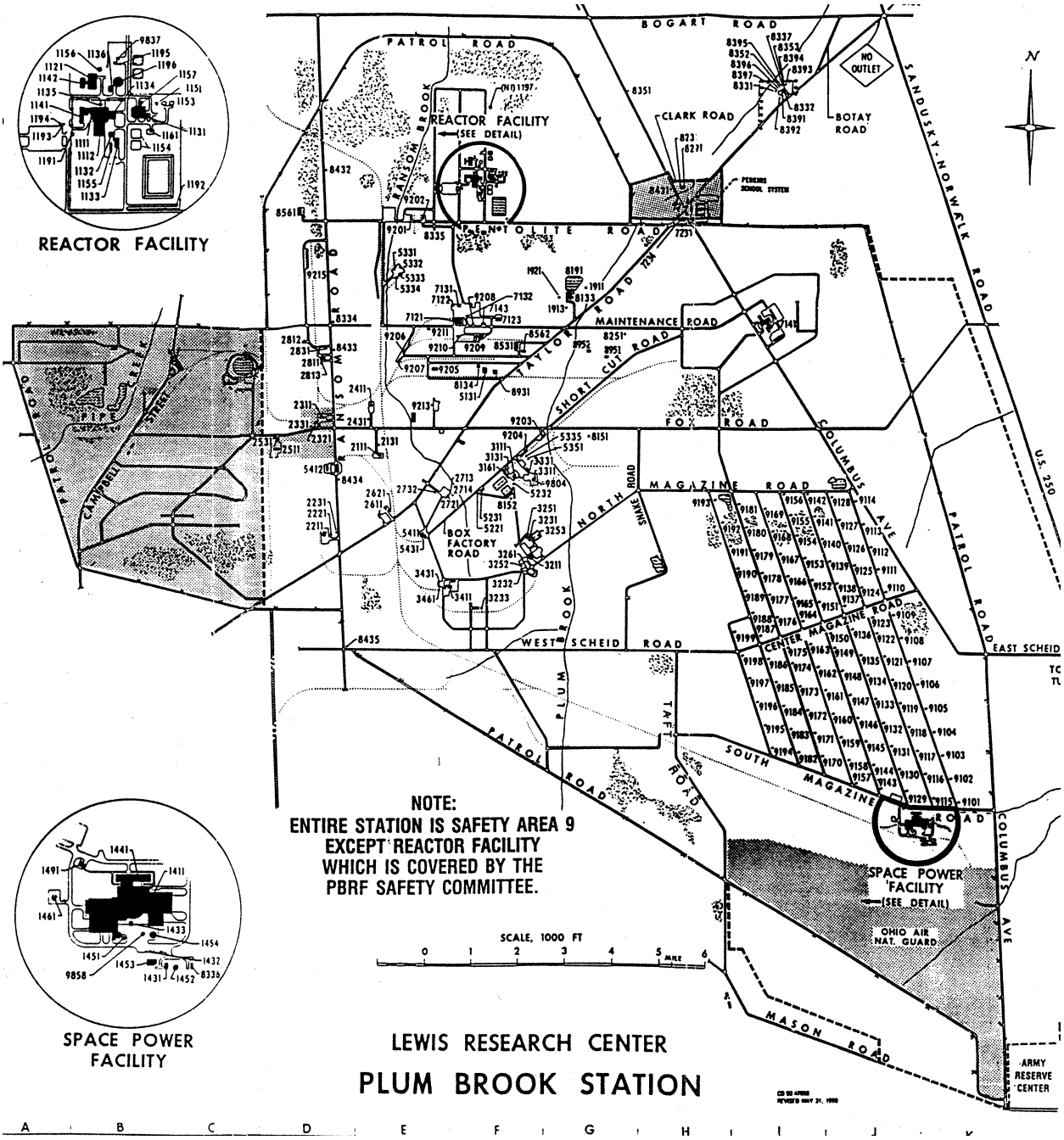

FIGURE 2. MAP OF PLUM BROOK STATION

Section 3 – Plant Communities of Plum Brook Station: presents the vegetation history, descriptions of the plant communities identified at PBS during 2001, and areas of special interest;

Section 4 – Plant Communities of Glenn Research Center: presents the vegetation history, descriptions of the plant communities identified at Lewis Field during 2001, and areas of special interest;

Section 5 – Uncertainties: discusses uncertainties with the maps and community descriptions;

Section 6 – Summary: briefly summarizes the report; and

Section 7 – References: lists the references cited throughout the report.

2. METHODS AND MATERIALS

The development of the plant community and aquatic resource map, community descriptions, and GIS occurred in several interrelated steps. Initially, existing data sources, including the Stennis Space Center draft GIS data layers, were obtained and reviewed. These data sources are listed and described in Section 2.1. Based on this review, a preliminary map of distinct plant communities was prepared for both PBS and Lewis Field. This map consisted of digitized plant community polygons overlain on aerial photographs delineating potential boundaries of distinct plant communities. The polygons were not coded with specific plant community classifications at this stage, rather they were numbered to enable accurate tracking of information obtained from the field.

Next field surveys were conducted at both PBS and Lewis Field to evaluate and document the existing plant communities (see Section 2.2). The scope of work required that five percent of the PBS area and all major plant communities at Lewis Field be surveyed. Due the large size, consistency, and easy access via an extensive road network, nearly all major (larger than 2 hectares) plant communities at PBS were surveyed rather than just five percent of the total area. All major plant communities at Lewis Field were surveyed.

Using data obtained from the field surveys, all plant communities including wetlands were classified according to the Federal Geographic Data Committee (FGDC) vegetation classification standard (see Section 2.3). In addition, polygon boundaries were revised as necessary to create the final map (see Section 2.4). The classifications were incorporated into a database linked to the plant community polygons. This spatially linked database is the basis for the ARC/INFO J GIS data layer GIS (see Section 2.5). This digital information system can be refined and updated as new information is collected, and as the plant communities are altered through land use changes, development, and/or natural succession.

2.1 Data Sources

Data sources used to assist with map preparation and initial plant community descriptions included the following:

Past Reports

The Ohio Department of Natural Resources (ODNR) previously conducted biological surveys at both Lewis Field (ODNR 1996) and PBS (ODNR 1995). The vegetation surveys in these reports provided summaries and plant species lists that were used to help identify important plant communities at the sites. These summaries and lists were updated in Volume I of the *Protected Species Management Strategy* (ODNR 2002).

Aerial Photographs

Black and white (B&W) orthoquad aerial photographs are already incorporated into the GIS developed by Stennis Space Center. These photos were used to define initial boundaries of distinct plant communities that were later refined based on the field surveys.

National Wetland Inventory Maps

National Wetlands Inventory (NWI) maps for the two quadrangles that cover PBS were used as indicators of potential wetland areas. These quadrangles include Sandusky (03-1977) and Kimball (04-1977). A single NWI quadrangle, Lakewood (03-1977), covers Lewis Field. These maps portray potential wetland communities based on aerial photograph interpretations and limited ground-truthing. Wetland communities are classified according to the Cowardin System (Cowardin et. al. 1979). Map scale is 1:80,000. USGS topographic maps are included as an overlay on the NWI maps. The wetland and topographic data were used to locate and define wetland communities in the field.

County Soil Surveys

County soil surveys for Erie (Redmond et. al. 1971) and Cuyahoga (Musgrave and Holloran 1980) counties prepared by the United States Department of Agriculture (USDA), Soil Conservation Service (Now known as the Natural Resource Conservation Service) provided soil type and boundary information. County soil surveys contain B&W aerial photographs and estimated boundaries of soil types. Hydric soil boundaries were used to help determine the presence of potential wetland areas.

2.2 Field Surveys

Field surveys were conducted at both PBS and Lewis Field to evaluate, document, and classify the plant communities and aquatic resources. The scope for this project required that PBS be divided into 5 acre (2 hectares) blocks of which at least 5 percent would be field surveyed. However, during the review of existing information and first site visit, it was determined that more of PBS could be

surveyed within the scoped level of effort. PBS has an extensive road network providing easy access to most locations. This road network in combination with relatively level topography, large open spaces, and landmarks (tall towers and buildings) made it easy to determine approximate locations in the field. In addition, many distinct plant communities are large (greater than 5 hectares) and uniform in composition making it easy to classify relatively large areas from a few surveying points. Based on these factors, it was determined that every distinct plant community larger than 2 hectares could be surveyed and many smaller ones also could be surveyed. Lewis Field is much smaller than PBS and much of Lewis Field is developed with building, roads, and parking lots. Due to its small size, all significant habitats at Lewis Field were surveyed.

Field surveys were conducted in distinct events supported by brief (one-day) site visits to both scope the sites and fill data gaps identified after the primary survey. Initial one-day site visits to conduct site reconnaissance and scope the field effort occurred in April and May, 2001. In June 2001, four field scientists (two teams of two) surveyed plant communities at PBS for five consecutive days. The initial survey was followed by three one-day site visits by two field scientists (one team of two) in the months of August, September, and October. At Lewis Field, the main survey was conducted in July 2001 for one day by two field scientists (one team of two). All natural and semi-natural areas were visited during this trip. This survey was followed by one half-day survey to classify areas with urban plant communities (lawns, ornamental trees, etc.) in the developed portions of the facility.

In order to visit all areas within the allotted time, surveying generally was limited to no more than 45 minutes in each selected plot. A rapid sampling technique was employed to determine appropriate plant community classification at each location. Appendix A contains an example of the data form developed to facilitate consistent and rapid sampling. The data form was used to establish the various types of communities and was then used as a reference for similar communities (i.e., a data form was not completed for every individual plant community). This form is a streamlined version of a data form developed by The Nature Conservancy (TNC 1998) for plant community surveys using the FGDC Vegetation Classification Standard. When a community was classified by reference a previously described community, specific notes such as dominant plant species were taken to record individual characteristics of the community. The data form specifies the collection of plant community attributes suitable for classification to the alliance level (see Section 2.3). Both physiognomic (e.g., dominant plant type such as herb, shrub, or tree as well as observed hydrology) and floristic (e.g., dominant species) characteristics were recorded. Data collection focused on dominant plant species as these are used to classify a plant community. Inventorying all species was not required, as an inventory of PBS and Lewis Field plant species was performed recently (ODNR 2002). The data forms were used to prepare the plant community descriptions presented in Sections 3 and 4.

The required resolution for the plant community maps specified a minimum mapping unit of five acres (2 hectares), but as noted previously, many smaller communities also were mapped and described. At each field survey location, the dominant community type found in the general area was described on the data form. In addition, data collection focused on a plot, a minimum of 10 meters in diameter that was believed to be representative of vegetation and general conditions throughout the community. Photographs were taken of representative or important communities to aid later data

interpretation. In addition, proposed revisions to community boundaries (i.e., polygons) developed during the initial phase of the project were noted in the field.

Following the field surveys, all data (forms, notes, photographs, maps) were assembled. These data were then interpreted in terms of providing a specific classification to these communities based on the observed species and physical conditions. This classification and mapping process is explained in Sections 2.3 and 2.4. Section 2.5 briefly explains the GIS data layers that accompany this report.

2.3 Community Classification

2.3.1 General Classification System

Plant communities were classified according to the FGDC Vegetation Classification Standard (FGDC 1997). This classification system includes a hierarchy of five physiognomic levels and two floristic levels, and is the approved standard for vegetation classification on federal lands.

Physiognomic Levels

Physiognomic Class
Physiognomic Subclass
Physiognomic Group
Subgroup
Formation

Floristic Levels

Alliance
Association

In the published version of the vegetation standard, the five physiognomic classification levels are complete within this standard, but floristic levels (alliance and association) are incomplete. TNC has developed a preliminary list of alliances for the Midwest and has begun developing a list of associations that is cross-listed with the ODNR preliminary plant community classification (Anderson 1982). The TNC system was used to classify communities to the alliance level. Currently, only alliance level classifications for natural "climax" communities have alliance designations (TNC 1997).

The FGDC system classifies plant communities in the physiognomic levels using the following core data:

- dominant life-form or vegetation stratum (i.e., tree, shrub, dwarf-shrub, herb, non-vascular);
- physiognomic attributes of the dominant vegetation stratum (e.g., evergreen, deciduous, etc.); and
- hydrologic regime of the site (Cowardin et. al. 1979).

The dominant life form is used to classify the plant community into one of the following seven classes: closed tree canopy (forests); open tree canopy (woodlands); shrubland; dwarf shrubland; herbaceous; non-vascular (bryophytes, lichens, and algae); and non-vegetated. Physiologic attributes and hydrologic regime are used to classify the community to the remaining physiognomic levels.

In general, the formation name is intended to provide the physiognomic description of the community type. However, formation names do not contain more familiar descriptions of communities, such as dominant plant species. This type of description is reserved for alliance and association classification levels.

2.3.2 Classification of Plant Alliances and Communities

The plant community descriptions provided in Sections 3 through 4 are based partly on the alliance summaries developed for Ohio by TNC 1997. However, discussion of features of these alliances (e.g., relative dominance of species) specific to the plant communities found at PBS and Lewis Field have been included. The discussion also identifies areas at PBS and Lewis Field that represent conditions typical of each alliance present at the site. A list of all Ohio natural alliances recognized by TNC (1997) are presented in Appendix C. Thirteen of these alliances were identified at PBS and six at Lewis Field during the survey.

TNC alliances are descriptions of intact, undisturbed natural and native ecological communities. However, an important general feature of the plant communities at PBS and Lewis Field is the abundance of disturbed or transitional communities. Previous to the acquisition of the property that became PBS, most of the area was cleared for agricultural use. Disruption by agricultural activities prior to the 1940s, construction and production activities during WWII, and uncontrolled plant succession and invasion of non-natives in the post-War period have eliminated any remnants of the grassland communities that once existed at PBS. The important plant community species themselves are present at PBS, but the actual plant communities are not. Lewis Field plant communities also are highly disturbed from past development.

In some cases, the forest communities at both sites have remained undisturbed for a sufficient time that they contain assemblages of plant species that a similar enough to TNC alliance descriptions that the use of TNC classifications are reasonably valid. This is also true for some herbaceous wetland communities. However, plant communities in many areas no longer resemble undisturbed native communities due to past disturbance. Early plant communities that become established following large-scale disturbance (e.g. recently abandoned agricultural fields) typically are dominated by herbaceous plants tolerant of sunlight and disturbed soil conditions. These herbaceous communities often are gradually replaced in a few years by woody species (shrubs and trees) that are tolerant of sunlight and colonize the herbaceous fields. Subsequently the dominance of shade-intolerant woody species is replaced by more and more shade-tolerant tree species that, in the absence of further large-scale disturbance, eventually will result in a mature forest. This progression of the different types of plant communities is termed Asuccession." The plant community Atransitions" or Asucceeds" in a directional fashion (i.e., herbaceous-dominated to shrub-dominated to tree-dominated). Noteworthy

stages of the succession often are termed successional communities, transitional communities, or seres.

Note that this example applies to locations where conditions favor the development of mature forest communities. In some locations such as pond edges and shallow water areas, forest communities may never develop. The persistent or Aclimax community" in these areas may be dominated by shrubs or herbaceous plants. One example is a shallow-water marsh where herbaceous species like cattails (*Typha* spp.) and bulrushes (*Scirpus* spp.) may persist indefinitely as the dominant plants as long as the shallow water conditions prevail. Some areas at PBS and Lewis Field have remained undisturbed for several decades, which is sufficient time for areas that are not favorable for forest communities to develop to already be colonized by the species that will persist in those locations. Other areas are maintained by periodic disturbance such as fire or flooding resulting in distinct plant assemblages adapted to disturbance regimes. Fire was an important factor affecting plant community composition at PBS, but not at Lewis Field.

Prior to European settlement, the directional succession at PBS was interrupted periodically by fire, which maintained large areas as herbaceous rather than woody vegetation. There is evidence that this disturbance by fire was often initiated by Native Americans in their pursuit of game animals. The presence of sandy soils also facilitated the maintenance of herbaceous communities. The result of this periodic disturbance was the establishment of prairie communities similar to tall grass prairies of the central Midwest for which TNC has developed alliance descriptions. These prairie communities contained plants species and assemblages plant species rarely found in Ohio. These communities were maintained by fire and should be viewed as the climax community for these areas rather than as successional stages to forest communities.

However, none of these, as distinct, identifiable prairie plant communities, presently exist at PBS. Most of the common or dominant species that define many of TNC alliances are present at PBS, but these species are nowhere assembled in intact plant communities that resemble the TNC descriptions. In some cases, small areas contain a predominance of rare prairie plants within a larger mosaic of disturbed plant communities.

These conditions pose problems with regards to classification. Communities that are composed of successional plant species (e.g., old fields) do not have floristic classifications at this time. Neither are there defined classifications for climax plant species mixed with successional plant species, or semi-natural communities created and/or maintained by humans (e.g., lawns). As a result, a generalized classification system has been developed for these communities. This classification was developed to be consistent with the FGDC classification system and the variation observed in these successional or maintained communities during the field survey. The fourteen successional or maintained communities are presented below and organized by FGDC formation.

Formation: I.A.8.N.c. Conical-crowned temperate or subpolar needle-leaved evergreen forest

- Needle-leaved evergreen forest

Formation: I.B.2.C.b. Orchards and groves (fruit and nut trees)

- Orchard

Formation: I.B.2.N.a. Lowland or submontane cold-deciduous forest – successional communities

- Mixed (oak-dominated) deciduous successional forest
- Mesic, mixed deciduous successional forest
- Mixed deciduous successional forest
- *Populus deltoides* successional forest

Formation: III.B.2.N.b. Temperate cold-deciduous shrubland – successional communities

- Dry mid-successional cold-deciduous shrubland
- Dry late-successional cold-deciduous shrubland

Formation: II.B.2.N.c. Intermittently flooded cold-deciduous shrubland – successional communities

- Intermittently flooded mid-successional cold-deciduous shrubland
- Intermittently flooded late-successional cold-deciduous shrubland

Formation: V.A.5.C.b. Landscaped urban/suburban/rural (residential yards, nurseries)

- Landscaped/Maintained grounds surrounding buildings

Formation: V.A.5.N.c. Medium-tall sod temperate or subpolar grassland

- Maintained grassland

Formation: V.B.2.N.a. Tall temperate or subpolar perennial forb vegetation – successional community

- Dry early successional herbaceous field

Formation: V.B.2.N.c. Intermittently flooded temperate perennial forb vegetation – successional community

- Intermittently flooded early successional herbaceous field

In Sections 3 and 4, those communities that have TNC (1997) alliance descriptions are referred to as Aalliances" and those that do not are referred to simply as Acommunities" (e.g., successional communities and maintained areas such as lawns and landscaped areas). It is important to note that these generalized classifications have the limitation of not identifying specific areas containing assemblages of rare plants that will be of importance for future management. For example, the *dry early successional herbaceous field* and *intermittently flooded early successional herbaceous field* communities at PBS include areas containing rare prairie plant assemblages as well as areas containing common assemblages of herbaceous plants in old fields. To overcome this limitation, Sections 3 and 4 of this report contain a discussion of important plant communities at PBS and Lewis Field, respectively. These discussions identify the areas that are important in terms the presence of rare species or a unique assemblage of species. Furthermore, these areas are identified in the GIS data layers. These areas will be addressed in more detail in Volume III: Management Plan.

2.3.3 Classification of Wetland Communities

Most wetland communities are covered by the plant community classifications within the FGDC standard; however, wetlands and aquatic communities also may be classified according to the Cowardin et. al. (1979) system, which is the standard approved by the FGDC and utilized by the NWI. A comparison of the Cowardin classification and FGDC vegetation classification is provided in Appendix B.

2.4 Mapping

Mapping of vegetation communities was conducted in two phases. A preliminary map was generated using the aerial photographs and other resources listed in Section 2.1. This project required that distinct communities five acres (2 hectares) or larger in size were to be documented on the map. During the mapping effort, some smaller communities that had distinct vegetation and boundaries were documented. Documentation consisted of drawing the preliminary borders of communities and subsequently digitizing them.

The field surveys provided plant community data for all large communities and many smaller ones at PBS and Lewis Field that allowed for the review and revision of boundaries established during aerial photograph interpretations. In addition, data collected on dominant plant species were utilized to classify plant communities to the first FGDC floristic level, the alliance. As discussed in Sections 2.3, community descriptions were developed for areas where a natural alliance was not present. Each distinct plant community polygon was correlated with a data record of the classification. Within the GIS, the color-coded polygons were associated with a database containing the complete FGDC physiognomic classification.

2.5 Geographic Information System

The companion deliverable for this project is an electronic data layer containing the plant community map and associated FGDC plant community classification. This data layer has been produced in ARC/INFO J format. The Content Standard for Digital Geospatial Metadata created by the FGDC in 1997 was the data documentation standard required for metadata. The data layers will be installed

into the GIS that Stennis Space Center is developing for NASA GRC's Environmental Office. As noted in Section 2.3, TNC alliance classification system does not currently provide alliance descriptions for transitional communities (e.g., old fields). Classification names for these communities have been included in the GIS alliance field; however, they are easily recognized because they do not end with the word, AAlliance". Color photographs of important plant communities also are included in the data layers.

3. PLANT COMMUNITIES OF PLUM BROOK STATION

3.1 Historical Context of PBS Plant Communities

The historical setting of PBS before European settlement is unique. Several rare or uncommon original plant communities occupied the site before modern settlement, including oak savannas and forests, and prairies of several types (Blakeman 1998). Proper management of PBS vegetation requires an understanding of the site's original vegetation and the ecological factors that controlled those plants and communities.

The descriptions of original vegetation below are derived from several authoritative sources. The first is from the first surveyor's field notes of the Firelands (now Erie and Huron Counties) of the Connecticut Western Reserve written in the field in the first decade of the 19th century. These field notes describe presettlement vegetation along the township and range line transects and therefore provide accurate first-hand records (Anonymous 1915). The second source of early landscape descriptions are found in several accounts in the *Firelands Pioneer*, a 19th century publication of the local Firelands Historical Society. A number of settlers recorded their recollections of early settlement days in the area in this local journal (Drake 1863 and Gurley 1863). Lastly, late 19th century atlases for each of the Erie County townships provide generalized descriptions of early settlement conditions (Anonymous 1874). Coupled with modern scientific understandings of native plant communities, an accurate description of the presettlement landscape vegetation of PBS has been constructed.

In brief, the history of PBS vegetation occurred in this sequence. Before European settlement, local plant communities were under the control of local Native Americans. Although there is no archeological evidence for significant dwellings, the area was frequently used for hunting. The combination of large open prairies, bordered by open grove-like oak savannas grading into solid forest to the north and west, provided an exceptionally wide diversity of wildlife habitats, perhaps more than any other equivalent locality anywhere in northern Ohio. These habitats supported both a diversity and large concentration of game animals (Blakeman 1998).

Most of wild habitats or plant communities at PBS were reduced to agricultural occupation in the last half of the 19th century. The majority of the site's soils are exceptionally fertile, a result of the centuries of the soil-building prairies of much of the area. The advent of the steel plow, effective drainage techniques, construction of local transportation infrastructure (roadways, railways, inter-urban passenger train lines), and access to Lake Erie and regional railroads all combined to complete intense agricultural exploitation of the area.

By the early 20th century, most of PBS was in agriculture. The large prairie areas were probably all in either row crop fields or domestic animal pasture. A few forests and savannas persisted, but many were altogether removed and converted to agriculture. The remnant forests and savannas remained probably as grazing and firewood sources.

By the time of the conversion of PBS to an ordnance manufacturing facility in the early 1940s, there were probably few or no intact native plant communities. Any remnant high-quality prairies or savannas that existed would have been very small, local patches. By the middle of the 20th century, the massive conversion of the site's vegetational landscape to modern agriculture was complete. Representative original plant communities were gone. Rare plants persisted only in hedgerows, field borders, roadsides, unused field corners, and other random areas.

One important distinction must be understood. Unlike other localities in northern Ohio, PBS properties were removed from agriculture at the beginning of World War II before the widespread use of chemical herbicides. Historic weed control at PBS involved only mechanical and crop rotation means. Consequently, the plant species of the original plant communities were able to persist in small, locally-isolated populations in ditches, hedgerows, field corners, and similar sites. The absence of chemical weed control allowed many rare species to persist on the site, although not in their original plant communities.

This locally unique sequence of human land use patterns accurately accounts for the persistence the many rare plants on the site. First, these species occurred commonly in the area in large landscape-scale prairies and savannas before European settlement. Then, European settlement and land use patterns facilitated the isolated local survival of the original plants, but not the rare communities themselves. As elsewhere, the activities of the European settlers destroyed the original plant communities. But they did not altogether extirpate the constituent plant species. These survived in waste areas and continue their local presence today.

Significant Effects of Landscape Fire

None of the historic events cited above are as significant as the frequent presence of landscape fire at PBS. The extensive presettlement prairies of the region originated in a long period of drought from 4000 to 8000 years before present, a period known as the Xerothermic. During this ancient hot and dry period, climatic factors favored the establishment of prairie communities.

But climatic patterns similar to the modern ones returned to Ohio at the end of the Xerothermic Period (at least 4000 years ago), and prairie plants and communities would have naturally reverted to native deciduous forest. This, in fact, occurred throughout most of Ohio. But in a few areas, extensive prairie landscapes persisted. These included the Darby Plains west of Columbus, the Sandusky Plains in the Marion-Upper Sandusky area, and in much of Wood County. One of the largest prairie areas was the great Firelands Prairie of Erie and Huron Counties, which included PBS (Gordon 1969).

The persistence of these prairie landscapes can be accounted for only by the frequent occurrence of landscape fire. PBS, along with the other Ohio prairie areas, has sufficient moisture and soils to support dense forests. But for centuries, frequent landscape fires prevented overgrowth of forest into the prairies. Forest trees are generally restricted by frequent fire. Prairie plants all thrive after fire. Landscape fires significantly altered normal vegetation patterns and caused the persistence of the area's many rare prairie plants (Gordon 1969).

Contrary to some theoretical explanations involving lightning, the landscape fires of PBS, even in the earliest times, were deliberately set by humans. Native Americans used landscape fire in Ohio prairies and forests for a number of important outcomes. It is known that prairie grasses growing following a fire have elevated levels of proteins. Thus, deer and other grazers were attracted to newly burned prairie areas where highly nutritious new grass promoted reproduction and successful nurturing of offspring. Burning therefore tended to attract and concentrate game animals for human use. Deer were commonly moved and concentrated by human-set "ring fires" in local prairies. Such fires were expertly used to herd deer into areas where they could be easily slain for human food and clothing (Blakeman 1998).

After settlement, European agriculturalists continued the use of fire to control vegetation in hedgerows, pastures, ditches, roadsides, and other non-crop areas, perpetuating the rare plants in these isolated refugia.

Landscape fire at PBS was absent during World War II and from the 1950s through the 1970s. Vegetation was controlled by extensive mowing. At some time in the late 1960s or 1970s extensive landscape mowing ended, and overgrowth by weedy and woody shrubs began in earnest, resulting in large areas of impenetrable thickets. Later, NASA personnel began burning to control the woody plant invasion. Such burns during March and April in the 1980s and 1990s successfully restored large areas to more natural, meadow-like vegetation and restrained encroachment of woody shrubs and thickets. These modern fires emulated the historic ones and the site's rare plants, near local extirpation, responded with increased growth. These late 20th century fires saved most of the area's rare plants.

The historic prairie fires commonly burned into the adjacent wooded areas, accounting for the prevalence of various oak (*Quercus*) species, all of which are adapted to frequent fire. Fires in PBS forests created open, park-like forests with no entangling underbrush. Native Americans were known to burn forests throughout Ohio to attain this favorable condition, which enabled easy travel and increased visual security opportunities. The burning of PBS forest floors was as historically common as the burning of the open prairies.

One of North America's rarest plant communities is the oak savanna, an area with particular ground level grasses and forbs ("wildflowers") beneath scattered oaks. Unlike in authentic closed-canopy oak forests, savanna trees were spaced far enough apart to allow sunlight to reach the ground between the trees. These rare communities were a combination of prairie and forest, with many prairie plants growing in between the wide-spread oaks. In some areas the oaks formed a more forest-like closed canopy environment, whereas on the edges, closer to prairie, the trees became less

dominant. PBS likely had a number of savannas in early times. Remnants of these persist. They are described in Sections 3.2 and 3.3.

In summary, the historical human uses of the PBS landscapes, by both Native Americans and European settlers, are unique and significant. Most of the original plant communities are now rare.

3.2 PBS Plant Communities in 2001

The following summaries describe plant communities identified at PBS during the 2001 survey. Locations of these plant communities are portrayed on Plate 1. The descriptions are organized according the FGDC formations: forests, woodlands, shrublands, herbaceous vegetation, non-vascular vegetation, and non-vegetated areas. The descriptions are general in nature and focus on dominant plant species. Section 3.3 contains a focused discussion of rare or otherwise important communities.

3.2.1 Forest Formations

Forest formations at PBS correspond to plant communities with closed tree canopies. Note that some areas at PBS contain plant communities dominated by tree species, but intermixed with patches of shrubs as a result of past disturbance. In general, these areas were classified as forest communities although the canopy is somewhat open in the shrub patches. This procedure was adopted to maintain consistency with the minimum mapping unit of five acres in which small patches of differing vegetation are not distinguished from the dominant vegetation type. Descriptions of the forest formations and the corresponding alliances and communities that were identified during the survey follow. Note that all formation names appear in bold and are preceded by their five character FGDC code. Alliance and community names are underlined and are followed by the code used to identify them on Plates 1 and 2.

Formation: I.A.8.N.c. Conical-crowned temperate or subpolar needle-leaved evergreen forest

Needle-leaved evergreen forest (EFU1)

This community is characterized by small mature stands of various conifers such as spruces (*Picea* spp.) and pines (*Pinus* spp.) in landscaping and other planted areas. White pine (*Pinus strobus*) generally is not dominant in these stands. Other than short grasses, very little understory or herbaceous vegetation is present. This is a relatively minor component of PBS and is not a natural community for the area. Generally, these areas are too small to map, but an example can be found at the intersection of Taylor and Pentolite Roads where a small stand of Norway spruce (*Picea abies*) is present.

Formation: I.B.2.C.b. Orchards and groves (fruit and nut trees)

Orchard (OR)

This community describes old orchards that have been unmaintained for at least several decades. Lack of maintenance has allowed colonization of these areas by shrubs, small trees, and often a thick herbaceous layer, but fruit trees generally still dominate the canopy. Orchards are a minor component of the PBS forests and generally are too small to map. One example, a small crabapple (*Malus spp.*) orchard, is located near the southern tip of the PBS property. Wild apple (*Malus sylvestris*) trees occur sporadically across PBS.

Formation: I.B.2.N.a. Lowland or submontane cold-deciduous forest

Fagus grandifolia - Acer saccharum - (*Liriodendron tulipifera*) Forest Alliance (FU1) - Photo 1

This forest alliance describes a diverse community common to mesic, gently sloping sites throughout the east-central United States and southern Canada. At PBS, this community is very rare. A single, large community is located north of South Patrol Road in the West Area (the peninsula area west of Ransom Road). It straddles a single, little-used NW-SE-trending road intersecting Taylor Road in the southwest corner of the Station. It is characterized mature deciduous trees on gently rolling topography with a near absence of underbrush. It has a park-like appearance with a moist forest floor covered by short grasses and ferns. At PBS, American beech (*Fagus grandifolia*) is mostly absent from the community. Sugar maple (*Acer saccharum*) and red maple (*Acer rubrum*) dominate the canopy. Other common trees include yellow-poplar (*Liriodendron tulipifera*), northern red oak (*Quercus rubra*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), and occasionally white oak (*Quercus alba*). The absence of American beech is possibly as a result of the length of time of forest development since the last period of disturbance (i.e., there has been insufficient time for the species to invade the site and become established). Mayapple (*Podophyllum peltatum*), wood nettle (*Laportea canadensis*), and ferns (e.g., *Dryopteris carthusiana*) were frequently observed in the herbaceous layer. The Anderson (1982) classification "Beech-Sugar Maple Forest@ also is used to describe this alliance.

Quercus alba - (*Quercus rubra*, *Carya* spp.) Forest Alliance (FU2) - Photo 2

This alliance is one the least abundant of the deciduous upland forest types found at PBS. It is found on well-drained sites often in gently sloping areas. Characteristic species include white oak (*Quercus alba*), northern red oak (*Quercus rubra*), shagbark hickory (*Carya ovata*), and shingle oak (*Quercus imbricaria*). Less abundant species include American basswood (*Tilia Americana*), red maple (*Acer rubrum*), wild black cherry (*Prunus serotina*), black walnut (*Juglans nigra*) and green ash (*Fraxinus pennsylvanica*). The understory is fairly open, but flowering dogwood can be common (*Cornus florida*). The herbaceous layer is generally sparse, but wood nettle (*Laportea canadensis*) is common in places. In some locations, stands of this forest type dominated by large white oak appear to have been planted. Two stands of this forest type are present southwest of the intersection of Ransom and Pentolite Roads. A third is located west of Ransom Road between Fox and South Patrol Roads. This last community is located on several sandy ridges and is less mesic due to the well-drained soils. The Anderson (1982) classification AOak-Hickory Forest@ also is used to describe this alliance.

Quercus rubra – Acer saccharum – (*Quercus alba*) Forest Alliance (FU3) – Photo 3

This alliance is located primarily in the northern portions of PBS north of Pentolite Road. The largest tract is north of the reactor facility. It is a mesic community dominated by mature northern red oak (*Quercus rubra*). Sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), and basswood (*Tilia Americana*), and white oak (*Quercus alba*) also are abundant in the canopy. The understory is fairly open containing saplings of canopy trees and frequently dogwood (*Cornus florida*). Patches of mayapple (*Podophyllum peltatum*) and wood nettle (*Laportea canadensis*) appear in the herbaceous layer, but frequently ground cover is nearly absent. The Anderson (1982) classification "Oak-Maple Forest" also is used to describe this alliance.

Quercus veluntina – Quercus alba Forest Alliance (FU4) – Photo 4

This alliance is rare regionally and PBS contains some of the few remaining examples. It occurs adjacent to or within former prairie areas. Historically these communities were maintained by fire, which prevented invasion by other woody species and maintained the grassland understory. Oaks dominate the overstory, but may be less dense than in more mesic communities. In addition trees may be shorter and more brushy. Black oak (*Quercus veluntina*) and white oak (*Quercus alba*) are the two most common canopy species. Hickory (*Carya* spp.) also may be relatively abundant. The herbaceous layer typically contains grasses and forbs including some typical prairie species. Little bluestem (*Schizachyrium scoparium*), poverty grass (*Danthonia spicata*), and panicled tick-trefoil (*Desmodium paniculatum*) are locally abundant. The Anderson (1982) classification "Oak Savanna" also is used to describe this alliance.

Mixed (oak-dominated) cold-deciduous successional forest (FU5) – Photo 5

Many areas of PBS contain young forest communities developing on previously cleared or otherwise disturbed land. There are several variations of this successional forest type each characterized by the relative abundance of the dominant tree species, most of which are early colonizers of disturbed areas. The mixed (oak-dominated) type occurs mainly in the southern portions of PBS and is characterized by a predominance of shingle oak (*Quercus imbricaria*) and pin oak (*Quercus palustris*). Black cherry (*Prunus serotina*) also is abundant. The understory is fairly dense often containing blackberry (*Rubus occidentalis*) and gray dogwood (*Cornus racemosa*). Poison ivy (*Toxicodendron radicans*) is relatively rare at PBS, but does occur in this community.

Mesic, mixed cold-deciduous successional forest (FU6) – Photo 6

This successional forest community is distinguished by the relatively higher abundance of mesic and hydrophytic species in both the overstory and understory. Cottonwood (*Populus deltoides*), pin oak (*Quercus palustris*), red maple (*Acer rubum*), and sassafras (*Sassafras albidum*) are common canopy trees. The canopy can be somewhat open allowing a relatively dense understory containing gray dogwood (*Cornus racemosa*) grape vines (*Vitis* spp.) and occasionally willow (*Salix* spp.) patches. Examples of this community are located along the South Patrol road in the southern portion of PBS.

Mixed-Deciduous successional forest (FU7) - Photo 7

This transitional forest community is fairly abundant at PBS and is indicative of a late stage of recovery following significant disturbance (e.g., clear-cutting). A mixture of pioneer species forms the somewhat open canopy. It is somewhat drier than the mesic, mixed succesional forest. Common species include white ash (*Fraxinus americana*), green ash (*Fraxinus pennsylvanica*), wild black cherry (*Prunus serotina*), red maple (*Acer rubrum*), black locust (*Robinia pseudoacacia*), and cottonwood (*Populus deltoides*). Generally, thick shrub and herbaceous layers are present characterized by old field species such as gray dogwood (*Cornus racemosa*), blackberry (*Rubus occidentalis*), hawthorn (*Crataegus* spp.), goldenrod (*Solidago* spp.), sheep sorrel (*Rumex acetosella*), and various grasses. Many examples of this community are located in the magazine areas and southern and western portions of PBS.

Populus deltoides successional forest (FU8) – Photo 8

This forest community is characterized by a very high abundance of cottonwood (*Populus deltoides*). In many cases, pure stands of similar-aged cottonwood are present. There is relatively little understory and the herbaceous layer is frequently composed of dense grasses. This community occurs most frequently north of Fox Road where many isolated stands of cottonwood are present in the open fields.

Formation: I.B.2.N.d. Temporarily flooded cold-deciduous forest

Fraxinus pennsylvanica - Ulmus americana - Celtis (*occidentalis*, *laevigata*) Temporarily Flooded Forest Alliance (FL1)

This forest alliance is associated with floodplains near streams and rivers and other temporarily flooded areas. It is quite rare at PBS, but not uncommon regionally. Characteristic tree species include green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), hackberry (*Celtis occidentalis*), and red maple (*Acer rubrum*). Black walnut (*Juglans nigra*), white ash (*Fraxinus americana*), cottonwood (*Populus deltoides*), sycamore (*Platanus occidenatlis*) also may be present. The understory and shrub layers are a somewhat dense and include American elm and green ash saplings. Herbaceous species include wingstem (*Verbesina alternifolia*), jewelweed (*Impatiens biflora* and *I. pallida*), false nettle (*Boehmeria cylindrica*), jack-in-the-pulpit (*Arisaema triphyllum*), smartweeds (*Polygonum* spp.), sedges (*Carex* spp.), and many others. A young example of this community is located north of Pentolite Road, east of the reactor facility. It appears to be an area where standing water may be present during the spring. The ODNR (1993) plant community study used the Anderson (1982) classification "Maple-Ash Swamp" and AMixed Floodplain Forest" to describe this alliance.

Salix nigra Temporarily Flooded Forest Alliance (FL2)

This floodplain forest alliance is a very minor component of PBS. It is generally found immediately adjacent to streams. The alliance is characterized by black willow (*Salix nigra*) as the dominant tree species in association with other less abundant species such as cottonwood (*Populus deltoides*), American elm (*Ulmus americana*), and green ash (*Fraxinus pennsylvanica*). The shrub and

herbaceous layers generally are dense and similar in composition to the same layers in the *Fraxinus pennsylvanica - Ulmus americana - Celtis* (*occidentalis, laevigata*) Temporarily Flooded Forest Alliance. A small example of this alliance is located just east of the intersection of Taylor and Maintenance Roads along Plum Brook.

Formation: I.B.2.N.e. Seasonally flooded cold-deciduous forest

Acer rubrum - Fraxinus pennsylvanica Seasonally Flooded Forest Alliance (FL3) - Photo 9

This forest alliance contains a mixture of upland, mesic species in combination with hydrophytic species. It is located in areas subject to seasonal flooding. Characteristic species include red maple (*Acer rubrum*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), pin oak (*Quercus palustris*), and swamp white oak (*Quercus bicolor*). Shagbark hickory (*Carya ovata*), wild black cherry (*Prunus serotina*), American basswood (*Tilia americana*), and northern red oak (*Quercus rubra*) also may be present. American elm saplings and dogwoods (*Cornus* spp.) often are present in the understory. The herbaceous layer is frequently absent, but often fallen limbs cover the forest floor. A large example of this alliance is located in the northern portion of PBS, north of Pentolite Road and west of the reactor facility. The ODNR (1993) plant community study used the Anderson (1982) classification "Mixed Swamp Forest" to describe the presence of this alliance.

Quercus palustris - (*Quercus bicolor*) Seasonally Flooded Forest Alliance (FL4) - Photo 10

This forest alliance is characterized by species tolerant of seasonally saturated or inundated conditions. Standing water (e.g., vernal pools) is often present in the spring and early summer. By late summer and fall, these areas generally are dry. Pin oak (*Quercus palustris*), swamp white oak (*Quercus bicolor*), and red maple (*Acer rubrum*) are the dominant tree species. American elm (*Ulmus americana*) is frequently present in the understory. The shrub and herbaceous layers frequently consists of dogwoods (*Cornus* spp.), jack-in-the-pulpit (*Arisaema triphyllum*), skunk cabbage (*Symplocarpus foetidus*), sedge species (*Carex* spp.) and various grasses. There appear to be two different types of this forest at PBS depending on surface topography and underlying geology. The first is more typical of the alliance and shows evidence of surface ponding during the spring with herbaceous hydrophytes fairly common. An example of this type is located west of Ransom Road near the southern boundary of PBS. The second type does not display evidence of surface ponding nor are herbaceous hydrophytes particularly common. Shallow groundwater appears to sustain the hydrophytic tree species. An example of this type is located along the East Patrol Road north of Fox Road. The Anderson (1982) classification "Oak-Maple Swamp" also is used to describe this alliance.

3.2.2 Woodland Formations

Woodland formations at PBS correspond to plant communities with open tree canopies. There were no woodland formations identified during the survey. Early successional areas that contained sporadic trees intermixed with shrubs were classified as shrub formations. Savannas were classified

as forest communities. According to the TNC system, only one woodland formation, *II.A.4.N.b. Conical-crowned temperate or subpolar needle-leaved evergreen woodland*, occurs in Ohio.

3.2.3 Shrubland Formations

Shrubland formations at PBS correspond to plant communities where the dominant life form is shrub. The term shrub corresponds to both true shrub species and young tree species (seedlings and saplings). For example, successional areas at PBS that contain young trees or young trees mixed with shrubs were classified as shrubland if the majority of the vegetation did not exceed 7 meters (~ 20 feet) in height. Note that many areas at PBS that were classified as shrubland are successional areas comprised mostly of young trees mixed with shrubs (i.e., mature old fields). Without disturbance, many of these areas will probably develop into young forest communities within approximately 5 - 15 years. Descriptions of the shrubland formations and the corresponding alliances and communities identified during the survey follow.

Formation: III.B.2.N.a. Temperate cold-deciduous shrubland

Dry mid-successional cold-deciduous shrubland (SU1) - Photo 11

The Dry mid-successional cold-deciduous shrubland community describes a plant grouping at PBS that is frequently encountered in previously disturbed areas (e.g., former agricultural fields or cleared/burned areas) that have had sufficient recovery time for invasion by shrub species. This community is present throughout PBS covering large (> 10 acres) as well smaller areas (< 1 acre). It is characterized by shrub species covering more than 50 percent of the area with relatively few large trees (> 7 m or ~ 20 ft. in height). Common shrub species include gray dogwood (*Cornus racemosa*), blackberry (*Rubus occidentalis*), hawthorn (*Crataegus* spp.), and multiflora rose (*Rosa multiflora*). Typical pioneer tree species include pin oak (*Quercus palustris*), cottonwood (*Populus deltoides*), red maple (*Acer rubrum*), wild black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), and black locust (*Robinia pseudoacacia*). A dense herbaceous community is present with common species such as goldenrod (*Solidago* spp.), dogbane (*Apocynum cannabinum*), self-heal or heal-all (*Prunella vulgaris*), yarrow (*Achillea millefolium*), strawberry (*Fragaria virginiana*), black-eyed Susan (*Rudbeckia hirta*), sheep sorrel (*Rumex acetosella*), fescue grasses (*Festuca* spp., mostly *Festuca arundinacea*), and other grasses. Many large areas between Pentolite and Fox Roads contain this community. This community is also commonly referred to as an "Old Field Community."

Formation: III.B.2.N.c. Intermittently flooded cold-deciduous shrubland

Intermittently flooded mid-successional cold-deciduous shrubland (SL1)

Species and age composition of the Intermittently flooded mid-successional cold-deciduous shrubland community is very similar to the Dry mid-successional cold-deciduous shrubland community. However, this community is characterized by the presence of additional species found in wet environments. These hydrophytic species are generally found in patches in scattered,

depressional areas and do not dominate the community. Patchy saturated soils and evidence of previous ponding also characterize this community. Shrub and young tree species include willows (*Salix nigra* and *S. discolor*), silky dogwood (*Cornus amomum*), eastern cottonwood (*Populus deltoides*), and occasionally quaking aspen (*Populus tremuloides*). Patches of sedges (*Carex* spp.), rushes (*Juncus* spp.), and bulrushes (*Scirpus* spp.) also are present. The magazine area contains a number of examples of this community.

Intermittently flooded late-successional cold-deciduous shrubland (SL2) - Photo 12

This community is more advanced stage of the slightly wet "Old Field Community" (see Intermittently flooded mid-successional cold-deciduous shrubland). In some cases, it is characterized by very dense patches of mature gray dogwood (*Cornus racemosa*) (3 to 5 m in height). The dense dogwood canopy retains significant ground moisture. In other cases, young pioneer trees generally less than 7 m in height are dominant. Common species include pin oak (*Quercus palustris*), red maple (*Acer rubrum*), eastern cottonwood (*Populus deltoides*), and green ash (*Fraxinus pennsylvanica*). Other shrub and herbaceous species are still present although to a lesser extent than in younger stages of the "Old Field Community." An example of this community is located along the eastern boundary of PBS between Columbus Avenue and East Patrol Road.

Formation: III.B.2.N.f. Semipermanently flooded cold-deciduous shrubland

Cephalanthus occidentalis Semipermanently Flooded Shrubland Alliance (SL3) - Photo 13

This shrub swamp alliance is quite rare at PBS. It is dominated by woody species including buttonbush (*Cephalanthus occidentalis*), common elder (*Sambucus canadensis*), willows (*Salix* spp.), and dogwoods (*Cornus* spp.). Pin oak (*Quercus palustris*) and red maple (*Acer rubrum*) are found in less inundated border areas. Herbaceous species include false nettle (*Boehmeria cylindrica*), mad-dog skullcap (*Scutellaria laterifolia*), beggar-ticks (*Bidens* spp.), manna grass (*Glyceria* spp.), sedges (*Carex* spp.), cinnamon fern (*Osmunda cinnamomea*), rice cut-grass (*Leersia oryzoides*), and smartweeds (*Polygonum* spp.). Floating aquatics such as duckweed (*Lemna* spp.) are common in deepwater areas.

This alliance occupies shallow water areas (e.g., depressions, ponds, floodplains) throughout the eastern United States. At PBS, an example of this community is located within a larger forest community, west of Taft Road and north of South Patrol Road. The shallow water areas of several ponds contain small examples of this community. The Anderson (1982) classification "Buttonbush Shrub Swamp" is also used to describe this community.

Formation: III.B.2.N.g. Saturated cold-deciduous shrubland

Cornus spp. - *Salix* spp. Saturated Shrubland Alliance (SL4) - Photo 14

This shrub swamp alliance is dominated by woody species including dogwood species (*Cornus* spp.), especially silky dogwood (*Cornus amomum*), sandbar willow (*Salix exigua*), pussy willow (*Salix discolor*), black willow (*Salix nigra*), and common elder (*Sambucus canadensis*). TNC (1997) also

reports the presence of additional shrub species such as meadow-sweet (*Spiraea alba*), speckled alder (*Alnus incana*) and black chokeberry (*Aronia melanocarpa*), but these species were not observed at PBS. Common herbaceous species include sedges (*Carex* spp.), reed canary grass (*Phalaris arundinacea*), rice cut-grass (*Leersia oryzoides*), and sensitive fern (*Onoclea sensibilis*).

The dogwood-willow swamp alliance occurs in two forms at PBS. The first occurs in moist openings and depressions where dense patches willow (*Salix* spp.) patch appear. A number of these patches occur in the open fields around the main office building on Columbus Avenue. The second type is a true dogwood-willow swamp. The best example is located within a wooded area east of Short Cut Road and north of Fox Road. This depressional area holds ponded water much of the year. It is one of the few areas at PBS able to support a large population of skunk cabbage (*Symplocarpus foetidus*). The Anderson (1982) classification "Mixed Shrub Swamp" is also used to describe this community.

3.2.4 Dwarf Shrubland Formations

Dwarf shrubland formations at PBS would correspond to plant communities where the dominant life form is dwarf shrub (e.g., cranberry - *Vaccinium macrocarpon*). According to the TNC system, only one dwarf shrubland formation, IV.A.1.N.g. Saturated needle-leaved or microphyllous evergreen dwarf-shrubland, has been described in Ohio. The dwarf shrubland formation was not identified at PBS during the survey.

3.2.5 Herbaceous Vegetation Formations

Herbaceous formations at PBS correspond to plant communities where the dominant life form is herbaceous (non-woody). Descriptions of the herbaceous formations and the corresponding alliances and communities identified during the survey follow.

Formation: A.5.C.b. Landscaped urban/suburban/rural (residential yards, nurseries)

Landscaped/Maintained grounds surrounding buildings (LM) - Photo 15

This community describes the maintained vegetation surrounding buildings. It is composed of mainly grasses that are mowed periodically and some ornamental trees and shrubs. Examples of this community may be found surrounding the main office buildings on Columbus Avenue and around the Space Power Facility.

Formation: V.A.5.N.c. Medium-tall sod temperate or subpolar grassland

Maintained grassland (MG) - Photo 16

This community refers to areas at PBS that were seeded with grass in the past and are currently maintained in a grassland condition through periodic mowing. This community is generally not located near buildings and is not part of the lawns associated with landscaping around buildings.

Some of these areas are used for avian research at the facility. The National Guard maintains large grassland areas in the southern tip of PBS.

Formation: V.A.5.N.k. Seasonally flooded temperate or subpolar grassland

Phalaris arundinacea Seasonally Flooded Herbaceous Alliance (HL2)

According to TNC (1997) this alliance occurs as a natural community in the northeastern United States, but its presence as a natural community elsewhere is uncertain. The alliance is dominated by reed canary grass (*Phalaris arundinacea*), which is a highly-invasive species. At PBS, the alliance occurs as a reed canary grass monoculture, but also occurs in combination with giant-reed (*Phragmites australis*), sweetflag (*Acorus calamus*), cattails (*Typha* spp.), rice cut-grass (*Leersia oryzoides*), and sedges (*Carex* spp.). This alliance is found most often in depressional areas and swales in previously cleared fields. An example of this community is located in the open field just south of the woodlot located directly across Pentolite Road from the reactor facility.

Typha spp. - (*Scirpus* spp. - *Juncus* spp.) Seasonally Flooded Herbaceous Alliance (HL3) – Photo 17

This shallow marsh alliance is characterized by cattails (*Typha* spp.), bulrushes (*Scirpus* spp.), rushes (*Juncus* spp.), giant bur-reed (*Sparganium eurycarpum*), big-leaved arrowhead (*Sagittaria latifolia*), duckweed (*Lemna* spp.), blue vervain (*Verbena hastata*), manna grass (*Glyceria* spp.), and water plantain (*Alisma subcordatum*). Cattails generally do not dominate this alliance. Rather, cattails, bulrushes, and rushes share dominance in approximately equal proportions in this formation. Saturated or inundated conditions prevail during much of the growing season, but water depths generally do not exceed 15 cm (~ 6 inches). Several examples of this community are located near ponds and ditches along North Magazine Road. The Anderson (1982) classification "Mixed Emergent Marsh" also is used to describe this community.

Phragmites australis Seasonally Flooded Herbaceous Alliance (HL4) – Photo 18

The community is characterized by the highly invasive giant reed (*Phragmites australis*) often occurring as a monoculture. The giant reed form dense tall stands, which exclude native plants. This community offers little habitat to wildlife and is highly undesirable due to its invasive nature. The roadside ditch along Pentolite Road across from the reactor facility contains this community. Several large patches occur in the field south of this ditch. The roadside ditch east of the Space Power Facility also contains this community.

Formation: V.B.2.N.a. Tall temperate or subpolar perennial forb vegetation

Dry early successional herbaceous field (HU1) - Photo 19

This community describes a frequent plant grouping at PBS that is present in recently disturbed areas that have not had sufficient recovery time for significant invasion by shrub species. In the former prairie areas, this is a natural and desirable condition because historically they were maintained by

fire. The community is characterized by dense herbaceous vegetation with common species including goldenrod (*Solidago* spp. and *Euthamia remota*), clasping-leaf dogbane (*Apocynum cannabinum*), self-heal or heal-all (*Prunella vulgaris*), yarrow (*Achillea millefolium*), strawberry (*Fragaria virginiana*), Ohio spiderwot (*Tradescantia ohiensis*), nodding thistle (*Carduus nutans*), foxglove (*Penstemon digitalis*), black-eyed Susan (*Rudbeckia hirta*), sheep sorrel (*Rumex acetosella*), and fescue grasses (*Festuca* spp., mostly *Festuca arundinacea*). Young shrubs frequently are present, but cover less than 50 percent of the area. Trees are rare. Common shrub species include gray dogwood (*Cornus racemosa*), blackberry (*Rubus occidentalis*), and multiflora rose (*Rosa multiflora*).

The most important examples of this community contain populations of rare prairie plants once common to the area. The locations of these rare plants are discussed in Volume I of the *Protected Species Management Strategy* (ODNR 2002). The central portion of PBS between Fox Road and Center magazine Road contains a very large example of this community.

Formation: V.B.2.N.c. Intermittently flooded temperate perennial forb vegetation

Intermittently flooded early successional herbaceous field (HL1) - Photo 20

Species composition of this community is very similar to the Dry early-successional herbaceous field community. However, this community is characterized by the additional presence of species found in wet environments such as sedges (*Carex* spp.), rushes (*Juncus* spp.), and bulrushes (*Scirpus* spp.). These hydrophytic species generally are found in patches in depressional areas and do not dominate the community. This community may extend into areas currently described as Dry early-successional herbaceous field; however, additional field verification would be required to further define these areas. One large example of this community is located the along East Patrol Road south of Fox Road. This field contains the largest population of the state-threatened ashy sunflower (*Helianthus mollis*) in Ohio. This community also contains the state-endangered rough rattlesnake root (*Prenanthes aspera*). Other less rare prairie plants such as little bluestem (*Schizachyrium scoparium*) also are present. Many other pockets of rare plants occur in similar herbaceous fields throughout PBS.

Formation: V.C.2.N.a. Permanently flooded temperate or subpolar hydromorphic rooted vegetation

Potamogeton spp. - *Ceratophyllum* spp. - *Elodea* spp. Permanently Flooded Herbaceous Alliance (HL5) - Photo 21

This alliance occurs in shallow open water areas generally less than 2 m deep. TNC (1997) defines this alliance as having up to 25% cover by emergents or floating-leaved aquatics and at least 25% submerged aquatics. Pondweeds (*Potamogeton* spp.), hornworts (*Ceratophyllum* spp.) and waterweed species (*Elodea* spp.) dominate the community. Small occurrences of this alliance exist in open water areas of many PBS ponds. The ponds between North Magazine Road and Fox Road contain good examples of this community. The Anderson (1982) classification "Submergent Marsh" also is used to describe this community.

3.2.6 Non-vascular Formations

Non-vascular formations at PBS correspond to plant communities where the dominant life form is non-vascular plant species. According to the TNC system, no non-vascular alliances have yet been classified for Ohio. No non-vascular formations were identified at PBS during the survey.

3.2.7 Non-vegetated Formations

Non-vegetated formations correspond to areas where vegetation is not the dominant cover type, but where vegetation normally would be present (e.g., plowed agricultural fields). It does not include developed areas such as roads and buildings. The non-vegetated formation, *VII.C.4.C.b. Non-agriculture disturbed areas*, is used to describe these areas. Unvegetated borrow pits are examples of this classification. Non-vegetated formations occupy only a few very small areas at PBS.

Several other non-vegetated features were noted on the map that have no corresponding vegetation name because they do not contain vegetation. These two features are deep water and gravel parking lot. Deep water (water 6' 6" deep or deeper) corresponds to ponds that were noted on the USGS topographical maps for the area. Gravel parking lot refers to constructed gravel lots of significant size (several acres or larger). These features were included in the vegetation data layer so that a complete coverage of the land surface could be produced.

3.3 Areas of Special Vegetation Significance at PBS

A number of sites have been identified by both field work and reference to historic data as areas of special ecological or vegetational significance. These include specific sites with identified populations of rare or state-listed plant species. They can be small and local, or somewhat extensive in area. But in all cases their distinguishing characteristic is that they support a growth of rare plants. The loss of any of these sites is likely to mean the irretrievable loss of the local rare plants, many of which are exceptionally rare or state-listed and found nowhere else in the region or state. These areas have been separated into three distinct categories, below.

Specific Rare Plant Sites

These are specific sites with identified populations of rare or state-listed plant species. They can be small and local, or somewhat extensive in area. But in all cases their distinguishing characteristic is that they support a growth of rare plants. The loss of any of these sites is likely to mean the irretrievable loss of the local rare plants, many of which are exceptionally rare or state-listed and found nowhere else in the region or state.

Intact Rare Plant Communities

These are entire, intact plant communities of ecological rarity, both at PBS and regionally. Common plant communities such as old field meadow, successional forest, and other commonplace communities are not included. Only plant communities known to be regionally rare or uncommon are listed.

Degraded Rare Plant Communities

Several rare or exceptional plant communities of ecological importance were identified in the field, but each is currently in an ecologically degraded, although not irretrievable condition. With proper management, each of these areas is likely to revert to a close approximation of its original, rare presettlement ecological conditions. These areas, even in their current degraded state, are exceptionally rare and should not be dismissed. The designation "degraded" does not in any way imply low value.

Management recommendations for each of these communities will be presented in the *Protected Species Management Strategy, Volume III: Management Plan.* Volume III also will discuss additional areas that show promise as rare plant community restoration areas. In most cases, many of the rare or uncommon native plants already occupy these sites, but not with appropriate frequency or density to be designated as important communities at the present time. However, these areas show promise as restoration sites for native plant communities.

The following discussion describes the location and significance of each of the rare plant or significant community sites identified during the 2001 survey.

3.3.1 Specific Rare Plant Sites

Each of these sites has known populations of regionally rare or state-listed plant species. Most of these species are found only at these sites, not throughout PBS. Therefore, these local sites have the highest ecological value of any on the PBS. The two sites described below have the greatest density of rare plants. The *Protected Species Management Strategy, Volume I: Biological Surveys* contains (ODNR 2002) locations of other rare plants located at PBS.

3.3.1.1 East Patrol Road Rare Prairie Plant Site

Location: All lands, especially including the actual ditch area, immediately west of East Patrol Road from the intersection of Fox Road south approximately 1400 ft to a depth to the west of approximately 800 ft. Plate 1 shows the majority of this area as Intermittently flooded early-successional herbaceous field.

Significance: This site contains the greatest number, both in specimens and species, of rare or state-listed plants of any location on PBS. Ohio's largest population of the very rare *Helianthus mollis,*

ashy or downy sunflower, occurs here with several thousand plants (Photo 22). This showy plant was until recently thought to be extirpated from most of the state until the discovery two local Erie County populations, this one being the largest.

Prenanthes aspera, rough rattlesnake root, an exceptionally rare (state-endangered) plant known otherwise from small isolated populations in southern Ohio, has been recently found growing on this PBS site. Several other uncommon or infrequent prairie plants are found in large numbers at the site, such as tall green milkweed (*Asclepias hirtella*), mountain mint (*Pycnanthemum tenuifolium*), arrow-leaved violet (*Viola sagittata*), common sneezeweed (*Helenium autumnale*), among others, indicating the ecological significance of the site.

3.3.1.2 Magazine Area

Location: This area involves all of the lands in the magazine area between North and South Magazine Roads. The vegetation growing on the tops of the magazines, and the magazine structures themselves, are not included. But the lands surrounding the individual magazines are vegetationally significant. As shown on Plate 1, plant communities in this area are highly diverse.

Significance: The magazine area has a great diversity of plant species, including many rare or state-listed ones. It also has a diversity of plant community types, including wetland sites, drier prairie-like communities, and several forest types, including wet pin oak forest [(*Quercus palustris* – (*Quercus bicolor*) seasonally flooded forest alliance].

Most significant are the frequent populations of many rare prairie species, including prairie false indigo (*Baptisia lactea*), Sullivant's milkweed (*Asclepias sulivantii*), several grasses, and others, in formerly excavated or disturbed sites adjacent to many of the magazine structures.

3.3.2 Intact Rare Plant Communities

Because of intensive agricultural and other modern human activities at PBS before its conversion to explosives manufacture, few intact plant communities of any ecological significance survive. Two existing forest areas, however, appear to be important native remnants with only minor modern disruption.

3.3.2.1 Pentolite Area Native Forests

Significant large, mature forests occur in the area north of Pentolite Road, north and west of the Reactor Facility.

Location: Much of forest north of Pentolite Road and west of the reactor facility is classified as red maple – green ash forest (*Acer rubrum – Fraxinus pennsylvanica* seasonally flooded forest alliance), a wetland category . A slightly less wet, but still mesic forest is present north of the reactor. This

forest is classified as red oak – sugar maple forest [*Quercus rubra – Acer saccharum – (Quercus alba*) forest alliance].

Significance: The forests in this area are outside of the original pre-settlement prairie area. They represent regional forests in poorly-drained areas. Species here are, for the most part, adapted to seasonally wet soils and shaded, closed-canopy deep forest conditions. No other large mature forest sites at PBS have these conditions. Few wet forest habitats survive in the region on the Ohio Lake Plain. The forest communities of this area are representative.

3.3.2.2 West Area Native Forest

Location: This is the forest area north of South Patrol Road in the West Area (the peninsula area west of Ransom Road). It straddles a single, little-used NW-SE-trending road intersecting Taylor Road in the southwest corner of the Station. Plate 1 shows this forest as the *Fagus grandifolia – Acer saccharum –* (*Liriodendron tulipifera*) forest alliance.

Significance: This forest area may be one of the most significant remnant forest areas in the Ohio Lake Plain. It is unique as a remarkable representation of Ohio forest conditions at the time of early settlement in the early 19th century. Early descriptions of Ohio forests universally describe their open, park-like conditions, free from underbrush or rank vegetation (see Photo 1). This condition resulted from frequent aboriginal woodland fires. Virtually no other present-day Ohio forest exhibits these conditions, as the vigorous suppression or prohibition of forest floor fires in the 20th century has allowed vegetation patterns of brush to proliferate.

This forest area, however, accurately represents the original, native Ohio forest. Frequent burning by NASA in the last 25 years has completely restored the original, presettlement condition. Unlike in other modern-day Ohio forests, virtually no non-native plants exist anywhere in this forest (except along the non-forest road right-of-way through the area).

Except for the previous removal of mature trees, the area is "virgin," maintaining the species and structure of the original forest. From a species presence concept, it is pristine. In time, as trees age, the forest will attain absolute maturity and replicate its historical ecological structure. The only reduced element in this forest community is the absence of mature trees, resulting from previous forestry activities. But constituent species are present and growing well after frequent landscape fires.

As a plant community, this forest area is quite rare. It contains no rare or state-listed plant species but as an ecological entity it is significant as a representation of the pre-settlement Ohio forest environment, lacking only exceptionally mature trees (previously logged). All other original forest elements are present in abundance, including significant size.

3.3.3 Degraded Rare Plant Communities

Significant, but degraded remnants of original savanna communities are found at several PBS locations. Savannas are exceptionally rare ecological communities intermediate between oak forest

and prairie. Classic prairie savannas have scattered open-growth (non-forest) oaks among prairie grasses and forbs adapted to the somewhat shaded conditions of a savanna.

Savannas are among the rarest North American plant communities, and PBS has several savannas in a degraded condition. None are pristine or currently of significant ecological quality. But their remnant structure and species composition persists, and with proper management they have the potential of significant restoration. They are designated on Plate 1 as black oak – white oak forest (*Quercus veluntina – Quercus alba* forest alliance).

Most of the PBS sites intergrade with or approach more dense oak forest conditions. They are located in areas that were either oak forest or open savanna during the first legal land surveys of the area in the first decade of the 19th century.

3.3.3.1 South Patrol Road and Taft Road Savanna Areas

Location: This includes the entire area north of South Patrol Road, west and east of Taft Road, and south of South Magazine Road. Specifically, the original native savanna probably surrounded and included the slightly elevated area paralleling and north of Patrol Road. Larger oaks presently occupy this ridge.

Significance: Tallgrass prairie savannas are among the rarest North American plant communities. Virtually no others exist in the Ohio Lake Plain on mesic or hydric soils. (Sand savannas are under restoration west of Toledo in the Oak Openings, but these are very different from the oak savannas of the original Firelands Prairie of which PBS was a part.) No local savanna in good condition exists.

This PBS savanna area is one of the very few sites in all of Ohio, or even the larger Midwest tallgrass prairie region yet open to any sort of ecological restoration. The site would not be presently regarded as an authentic savanna, but the presence of large, spreading open growth oaks, dappled ground level lighting, and the known existence of a savanna on the site in the early 19th century brings exceptional ecological significance to the site.

This is one of the rarest plant communities in the Midwest, even in its highly degraded state.

3.3.3.2 Pentolite Road Savanna Area

The two oak forests of this area, especially the eastern one, possess many elements of an authentic prairie oak savanna. From Pentolite Road both areas appear to be only typical woodlots, but on-site examination reveals significant savanna elements, including both large, widespread oaks and many characteristic savanna grass and forb species.

Location: The entire site includes forested and adjacent open areas surrounding the forests along Pentolite Road south of the Reactor Facility.

Significance: Overall the entire site is a representative disturbed savanna site. Specifically, the eastern forest area retains many elements, both in structure and species composition, of a local savanna. It is therefore an important ecological site.

4. PLANT COMMUNITIES OF LEWIS FIELD

4.1 Historical Context of Lewis Field Plant Communities

The composition of the original vegetation at the Lewis Field site is unknown, but its nature can be inferred. Lewis Field lies in the Beech-Maple Forest region of the great eastern Deciduous Forest of Eastern North America (Braun 1961). Gordon (1967) classified this region as a mixture of Beech Forest, Mixed Oak Forest, Elm-Ash Swamp Forest, and Mixed Mesophytic Forest. At Lewis Field, the uplands probably were dominated a mixture of Beech-Maple and Elm-Ash forests depending on local soil types and hydrology. The Abram Creek gorge provides a microclimate for more northern species and would be classified as a southern pocket of Hemlock-White Pine-Northern Hardwood Forest (Braun 1961). Mixed Mesophytic Forest likely was present on the slopes of the gorge. The terrace of Abram Creek is too narrow to support swamp forests or riverine woodlands. The original forest cover was removed probably during the early 1800's, destroying the natural vegetation. The denuded uplands likely were cultivated and/or grazed and subsequent continuing development has prevented the land from reverting to a natural state. Unlike PBS, fire was not a major factor affecting the composition of plant communities at Lewis Field.

Most of the site is now too highly disturbed to support significant numbers of indigenous Ohio plant species. Approximately 69 hectares (170 acres) at Lewis Field are considered undeveloped. The gorge of Abram Creek and the tops of the bluffs above the valley are the only areas that retain natural qualities. These areas contain forest communities similar to their original types.

4.2 Lewis Field Plant Communities in 2001

The follow summaries describe plant communities identified at Lewis Field during the 2001 survey. Locations of these plant communities are portrayed on Plate 2. The descriptions are organized according the FGDC formations: forests, woodlands, shrublands, herbaceous vegetation, non-vascular vegetation, and non-vegetated areas. The descriptions are general in nature and focus on dominant plant species. Section 4.3 contains a focused discussion of rare or otherwise important communities.

4.2.1 Forest Formations

Forest formations at Lewis Field correspond to plant communities with closed tree canopies. Descriptions of the forest formations and the corresponding alliances and communities that were identified during the survey follow. Note that all formation names appear in bold and are preceded

by their five character FGDC code. Alliance and community names are underlined. Referenced photos appear in Appendix D.

Formation: I.A.8.N.c. Conical-crowned temperate or subpolar needle-leaved evergreen forest

Needle-leaved evergreen forest (EFU1)

This community is characterized by small mature stands of various conifers such as spruces (*Picea* spp.) and pines (*Pinus* spp.) associated with planted areas. Virginia pine (*Pinus virginiana*) generally is dominant in these stands. The forest canopy is closed and very little understory or herbaceous vegetation is present. This is a very minor component of Lewis Field forests. Generally, these areas are too small to map, but an example can be in an open field west of the rocket engine test facility.

Formation: I.C.3.N.a. Mixed needle-leaved evergreen - cold-deciduous forest

Tsuga canadensis - Betula alleghaniensis Forest Alliance (MFU1) - Photo 23

This range of alliance extends from the Great Lakes region to the northeastern United States. The alliance is a closed canopy forest dominated by eastern hemlock (*Tsuga canadensis*) in combination with sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), and American beech (*Fagus grandifolia*). Additional associated species vary with region and may include red maple (*Acer rubrum*), sweet birch (*Betula lenta*), hickory species (*Carya* spp.), yellow-poplar (*Liriodendron tulipifera*), white pine (*Pinus strobus*), wild black cherry (*Prunus serotina*). At Lewis Field, birch and pine species are not present. The herbaceous layer generally is sparse. This is a rare alliance in Ohio, but is found at Lewis Field along most of the lower slopes of the Abram Creek gorge. The Anderson (1982) classification AHemlock-White Pine-Hardwood Forest@ is also used to describe this alliance.

Formation: I.B.2.N.a. Lowland or submontane cold-deciduous forest

Fagus grandifolia - Acer saccharum - (*Liriodendron tulipifera*) Forest Alliance (FU1) - Photo 24

This forest alliance describes a diverse community common to mesic, gently sloping sites throughout the east-central United States and southern Canada. At Lewis Field, much of the slopes of the Abram Creek gorge contain this alliance. Sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), and northern red oak (Quercus rubra) dominate the canopy. American beech (*Fagus grandifolia*) is present, but not common. Other trees include green ash (*Fraxinus pennsylvanica*), black cherry (*Prunus serotina*), various hickories (*Carya* spp.), and occasionally yellow-poplar (*Liriodendron tulipifera*) and white oak (*Quercus alba*). Spicebush (*Lindera benzoin*), American hornbeam (*Carpinus caroliniana*), eastern witch-hazel (*Hamamelis virginiana*), and eastern hop-hornbeam (*Ostrya virginiana*) were frequently observed in the understory. Grasses (*Poa* spp.), ferns (*Dryopteris* spp.), and garlic mustard (*Alliaria petiolata*), were frequently observed in the herbaceous

layer. The Anderson (1982) classification ABeech-Sugar Maple Forest@ also is used to describe this alliance.

Quercus rubra – Acer saccharum – (*Quercus alba*) Forest Alliance (FU3) – Photo 25

This alliance is located along the blufftops above Abram Creek and the Rocky River gorge. The most mature stand is located between Building 301 and West Area Road. It is somewhat drier than the *Fagus grandifolia - Acer saccharum* - (*Liriodendron tulipifera*) Forest Alliance , but still a mesic community. Northern red oak (*Quercus rubra*) is the dominant tree species. White oak (*Quercus alba*), sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), and bitternut hickory (*Carya cordiformis*) also are abundant in the canopy. The understory is fairly open containing saplings of canopy trees and frequently eastern hop-hornbeam (*Ostrya virginiana*) and young black cherry (*Prunus serotina*). Patches of jack-in-the-pulpit (*Arisaema triphyllum*), Pennsylvania sedge (*Carex pensylvanica*), and Virginia creeper (*Parthenocissus quinquefolia*) vines appear in the herbaceous layer, but frequently ground cover is nearly absent. The Anderson (1982) classifications "Oak-Maple Forest" also are used to describe this alliance.

Mixed-Deciduous successional forest (FU5)

This transitional forest community is fairly uncommon at Lewis Field and is indicative of a late stage of recovery following significant disturbance (e.g., clear-cutting). A mixture of pioneer species forms the somewhat open canopy. Common species include wild black cherry (*Prunus serotina*), red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), and bigtooth aspen (*Populus grandidentata*). Generally, thick shrub and herbaceous layers are present characterized by rasberry (*Rubus odoratus*), hawthorn (*Crataegus* spp.), goldenrod (*Solidago* spp.), sheep sorrel (*Rumex acetosella*), and fescue grasses (*Festuca* spp., mostly *Festuca arundinacea*). An example of this community is located along Cryogenic Road across from the sports fields.

Formation: I.B.2.N.e. Seasonally flooded cold-deciduous forest

Acer rubrum - Fraxinus pennsylvanica Seasonally Flooded Forest Alliance (FL3) - Photo 26

This forest alliance contains a mixture of upland, mesic species in combination with hydrophytic species. It is located in areas subject to seasonal flooding and is often located along streams. At Lewis Field, it occurs in a narrow band along a small drainage ditch in the western part of the facility. Characteristic species include red maple (*Acer rubrum*), red elm (*Ulmus rubra*), green ash (*Fraxinus pennsylvanica*), and quaking aspen (*Populus tremuloides*). Red elm and spicebush (*Lindera benzoin*) often are present in the understory. The Anderson (1982) classification "Maple-Ash Swamp/Forest" also is used to describe this alliance.

4.2.2 Woodland Formations

Woodland formations at Lewis Field correspond to plant communities with open tree canopies. There were no woodland formations identified during the survey. Early successional areas that contained sporadic trees intermixed with shrubs were classified as shrub formations. According to

the TNC system, only one woodland formation, *II.A.4.N.b. Conical-crowned temperate or subpolar needle-leaved evergreen woodland*, occurs in Ohio.

4.2.3 Shrubland Formations

Shrubland formations at Lewis Field correspond to plant communities where the dominant life form is shrub. The term shrub corresponds to both true shrub species and young tree species (seedlings and saplings). Without disturbance, many of these areas will probably develop into young forest communities within approximately 5 - 15 years. Regular maintenance (e.g., mowing) of open fields at Lewis Field prevents the establishment of woody species; therefore, shrubland formations occupy very little area. A single shrubland formation and the corresponding community was identified during the survey.

Formation: III.B.2.N.a. Temperate cold-deciduous shrubland

Dry late-successional cold-deciduous shrubland (SU2)

This community is more advanced stage of the AOld Field Community@ (see Dry early-successional herbaceous field). At this stage, young pioneer trees less than 7 m. in height are dominant. Woody species include red maple (*Acer rubrum*), wild black cherry (*Prunus serotina*), and quaking aspen (*Populus tremuloides*) combined with thickets (*Rosa* spp. and *Rubus* spp.). Shrub and herbaceous species are still present and correspond to those in the Dry early-successional herbaceous field. The single example of this community at Lewis Field is located along the southeastern boundary with the airport (behind trailer row) where regular mowing has not occurred.

4.2.4 Herbaceous Vegetation Formations

Herbaceous formations at PBS correspond to plant communities where the dominant life form is herbaceous (non-woody). Descriptions of the herbaceous formations and the corresponding alliances and communities identified during the survey follow.

Formation: V.A.5.C.b. Landscaped urban/suburban/rural (residential yards, nurseries)

Landscaped/Maintained grounds surrounding buildings (LM) - Photo 27

This community describes the maintained vegetation surrounding buildings. It is composed of introduced lawn grasses (*Poa* spp. and *Festuca* spp.), which are mowed regularly, and some ornamental trees and shrubs. Examples of this community may be found surrounding the operational buildings, sports fields, picnic grounds, and roadsides. This is one of the most common vegetation communities at Lewis Field.

Formation: V.A.5.N.c. Medium-tall sod temperate or subpolar grassland

Maintained grassland (MG) - Photo 28

This community refers to areas at Lewis Field that were seeded with grass (*Festuca* spp. and *Poa* spp.) in the past and are currently maintained in a grassland condition through periodic mowing (several times a year). Thus, it has a more natural appearance than landscaped areas. This community is generally not located near buildings and is not part of the lawns associated with landscaping around buildings. The old landfill areas in the South 40 area are covered by this type of vegetation. In addition, the grassy field west of the softball fields also contains the maintained grassland community.

Formation: V.A.5.N.l. Semipermanently flooded temperate or subpolar grassland

Typha (*angustifolia*, *latifolia*) - (*Scirpus* spp.) Semipermanently Flooded Herbaceous Alliance (HL4)

The cattail marsh alliance occurs along pond edges, roadside ditches, and shallow basins and is very common throughout the United States. The alliance is dominated by pure stands narrow-leaf (*Typha angustifolia*) and broad-leaf (*Typha latifolia*) cattails. Sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), and broad-leaf hydrophytic herbs also are common. Saturated or inundated conditions prevail during much of the growing season. A single example of this alliance is located around the perimeter of the coal-pile runoff pond in the South 40 Area. The Anderson (1982) classification "Cat-tail Marsh" also is used to describe this community.

Formation: V.B.2.N.a. Tall temperate or subpolar perennial forb vegetation

Dry early successional herbaceous field (HU1)

This community describes a plant grouping at Lewis Field that is present in recently disturbed areas that have not had sufficient recovery time for significant invasion by shrub species. It is characterized by a dense herbaceous community with common species including goldenrod (*Solidago* spp. and *Euthamia graminofolia*), self-heal or heal-all (*Prunella vulgaris*), yarrow (*Achillea millefolium*), strawberry (*Fragaria virginiana*), sheep sorrel (*Rumex acetosella*), timothy (*Phleum pratense*), Canada thistle (*Cirsium arvense*), chickory (*Cichorium intybus*), heath aster (*Aster pilosus*), scarlet pimpernel (*Anagallis arvensis*), redtop (*Agrostis gigantea*) and fescue (*Festuca* spp., mostly *Festuca arundinacea*), and other grasses. Young shrubs are occasionally present. Trees are rare. An example of this community is located along the western border of Lewis Field at the end of Cryogenic Road.

Formation: V.B.2.N.c. Intermittently flooded temperate perennial forb vegetation

Intermittently flooded early successional herbaceous field (HL1) - Photo 29

Species composition of this community is very similar to the Dry early-successional herbaceous field community. However, this community is characterized by the additional presence of species found in wet environments such as sedges (*Carex* spp.) and rushes (*Juncus* spp.) as well as invasive, mesic plants such as garlic mustard (*Alliaria petiolata*). These hydrophytic species generally are found in patches in low areas and do not dominate the community. One example of this community is located in the firing range area adjacent to Abram Creek.

Formation: V.C.2.N.a. Permanently flooded temperate or subpolar hydromorphic rooted vegetation

Potamogeton spp. - *Ceratophyllum* spp. - *Elodea* spp. Permanently Flooded Herbaceous Alliance (HL6)

This alliance occurs in shallow open water areas generally less than 2 m deep. TNC (1997) defines this alliance as having up to 25% cover by emergents or floating-leaved aquatics and at least 25% submerged aquatics. Pondweeds (*Potamogeton* spp.), hornworts (*Ceratophyllum* spp.) and waterweed species (*Elodea* spp.) dominate the community. The shallow pond north of Building 333, between Guerin and West Area Roads, contains vegetation that corresponds to this alliance. However, it is not as abundant as that cited in the TNC (1997) description. The Anderson (1982) classification ASubmergent Marsh@ also is used to describe this community.

4.2.5 Non-vascular Formations

Non-vascular formations at Lewis Field correspond to plant communities where the dominant life form is non-vascular plant species. According to the TNC system, no non-vascular alliances have yet been classified for Ohio. No non-vascular formations were identified at Lewis Field during the survey.

4.2.6 Non-vegetated Formations

Non-vegetated formations correspond to areas where vegetation is not the dominant cover type, but where vegetation normally would be present (e.g., plowed agricultural fields). It does not include developed areas such as roads and buildings. The non-vegetated formation, *VII.C.4.C.b. Non-agriculture disturbed areas*, is used to describe these areas. Non-vegetated softball diamonds and cleared areas are examples of this classification.

Several other non-vegetated features were noted on the map that have no corresponding vegetation name because they do not contain vegetation. These features are deep water , buildings, roads, and parking lots. Deep water (water 6' 6" deep or deeper) corresponds to ponds that were noted on the USGS topographical maps for the area. These features were included in the vegetation data layer so that a complete coverage of the land surface could be produced.

4.3 Areas of Special Vegetation Significance at Lewis Field

Unlike PBS, relatively few sites at Lewis Field have been identified as areas of special ecological or vegetational significance. Much of Lewis Field has been developed and Lewis Field is surrounded by developed areas. Thus, few rare plants or important communities are present. The forests of the Abram Creek gorge and the adjacent blufftops are relatively mature and have not been invaded by significant numbers of non-native species. These forests represent the most significant vegetation areas at Lewis Field. Abram Creek is a tributary to the Rocky River, which is surrounded by an

extensive forest corridor (Rocky River Reservation). Two plant species listed as potentially threatened in Ohio occur at Lewis Field and both occur in these forests. A single American chestnut (*Castanea dentata*) is located on the forested blufftop above the Rocky River behind Building 500. Several pigeon grape (*Vitis cinerea*) vines are located on trees on the blufftop east of Abram Creek and south of Building 142). These species and the mature forests along Abram Creek and the Rocky River should be protected to the extent practicable.

5. UNCERTAINTIES

Uncertainties associated with the plant community surveys are related to possible errors in data interpretation, extrapolations to unverified areas, and existing errors in other data sources used to make classifications. These uncertainties are discussed below.

One type of uncertainty associated with data interpretation is incorrect interpretation of photographic data. This type of error can result from poor photograph resolution, glare, or seasonal characteristics that do not typify the year-round plant community. Incorrect interpretation of aerial photographs will result in the mislabeling of plant community types. In general, this type of error results is mislabeling the formation, but higher levels of classification are still correct. For example, problems with determining hydrology may result in a forest community being labeled *I.B.2.N.d. Temporarily flooded cold-deciduous forest* when *I.B.2.N.e. Seasonally flooded cold-deciduous forest* is the correct formation. This type of error has been reduced significantly by conducting the field surveys during this project.

A second type of uncertainty associated with data interpretation is incorrect interpretation of site characteristics observed during field surveys. This type of error is expected to be low, especially in areas of woody vegetation, because dominant vegetation is a fairly permanent feature of a site and typifies the community classification. Hydrology also impacts community classification and is subject to seasonal and yearly fluctuations. Drought conditions were prevalent in Ohio in the late 1990s and may have obscured more typical conditions at some sites. It is likely that some areas dominated by herbaceous vegetation that were not identified as wet actually are intermittently or seasonally inundated. The greater permanence of shrub and tree species greatly reduces this type of error in shrublands and forests. Also, note that in general, plant community characteristics observed during the field verification were consistent with observations of previous studies (ODNR 1995 and 1996); therefore, descriptions of general plant community characteristics at PBS and Lewis Field are believed to be accurate and sufficient for the development of management strategies.

Another source of uncertainty is data extrapolation. Errors can occur when extrapolating from observed conditions in a field survey plot to the rest of the adjacent community. Community boundaries initially were established by aerial photograph interpretation. In many cases these boundaries were not altered unless field observed conditions necessitated their revision. Many of these polygons are large (e.g., tens of acres) and only small portions were observed in significant detail during the field survey. Therefore, it is possible that some polygons contain smaller distinct communities that were not identified during aerial photograph interpretation and this error has not been corrected because detailed survey did not occur in these locations. In general, this error is

believed to be restricted to alliance/community level classification. In other words, classifications of unsurveyed areas at the formation level are believed to be fairly accurate, but classification of unsurveyed areas to the alliance level may contain some errors.

All types of uncertainties have been reduced in the generation of the plant community map through the use of multiple data sources, including field surveys, prior to making final plant community interpretations.

6. SUMMARY

It is clear from the surveys that PBS contains vast natural resources in the form of a complex mosaic of plant communities in various successional stages and hydrologic regimes. Much of PBS is undeveloped natural areas or recovering natural areas previously used for agriculture. The size and diversity of natural habitats at PBS supports a large number of plant and animal species (see ODNR 2002). Many of these areas contain rare plants species and rare plant communities, including rare prairie species and remnant oak savannas.

Lewis Field is a much smaller facility in terms of land area compared to PBS, and proportionally it is much more developed. Although small, Lewis Field does contain some significant forest communities along Abram Creek.

Both sites support sensitive biological resources (rare plant and animal species and/or rare communities, ODNR 2002). The locations of these sensitive resources have been recorded and are represented on GIS data layers. These locations can be viewed with respect to the plant communities identified in this report to determine priority areas for conservation. Knowledge of these specific locations and the preferred habitat(s) as depicted in the plant community map will enable the development of a structured monitoring and management program as well as restoration programs, where appropriate. These maps and GIS data provide PBS and Lewis Field managers with a powerful tool to effectively manage the natural resources at PBS and Lewis Field. In addition, the GIS system can be quickly updated as additional information regarding the plant communities at PBS and Lewis Field are collected.

The plant community map also may be used to determine the usability of particular areas for future development. For example, all physiognomic formations with temporary or more frequent flooding (e.g., seasonal, semipermanently) contain potential jurisdictional wetlands. Proposed development areas that contain these habitats can be surveyed for jurisdictional wetlands and appropriate avoidance measures can be taken. In addition, knowledge of areas at the site that contain sensitive species or communities can be used in planning for development. Development can be structured to avoid these areas.

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APPENDIX A

FIELD VERIFICATION DATA FORM

NASA GRC and PBS PLANT COMMUNITY SURVEY

DATA FORM

IDENTIFIERS/LOCATORS

Plot Code_____ Polygon Code_____

Survey Date_____ Surveyors_____

Plot Location (Predetermined) - Latitude_____Longitude_____

GPS Field Survey Measurement - Latitude_____ Longitude_____

Plot Location Description:

Plot Photos (Y/N)_____ Roll Number_____ Frame Number(s)_____

ENVIRONMENTAL DESCRIPTION

Slope (estimated)_____ Aspect (compass)_____

Topographic Position_____

Landform_____

Surficial Geology_____

Cowardin System	**Hydrologic Modifiers**	
___Upland	**___Semipermanently Flooded**	**___Intermittently Flooded**
___Riverine	**___Seasonally Flooded**	**___Permanently Flooded**
___Palustrine	**___Saturated**	**___Temporarily Flooded**

Environmental Comments:

Determined in Office

Formation Designation_____

Alliance Designation_____

VEGETATION DESCRIPTION

Leaf Phenology (of dominant Strata)	Leaf Type (of dominant Strata)	Physiognomic Class	Cover scale for Strata & Unvegetated Surface		Height Scale for Strata	
Trees and Shrubs	___Broad-leaved	___Forest	01	<1%	01	<0.5m
___Evergreen	___Needle-leaved	___Woodland	02	1-5%	02	0.5-1m
___Cold-deciduous	___Microphyllous	___Shrubland	03	5-25%	03	1-2m
___Drought-deciduous	___Graminoid	___Herbaceous	04	25-50%	04	2-5m
___Mixed Evergreen-cold-deciduous	___Forb	___Nonvascular	05	50-75%	05	5-10m
___Mixed Evergreen-Drought deciduous		___Sparsely vegetated	06	75-100%	06	10-15m
Herbs					07	>15m
___Annual						
___Perennial						

Strata	Height Class	Cover Class	Diagnostic species (if known)
T1 Emergent	_____	_____	_____
T2 Canopy	_____	_____	_____
T3 Sub-canopy	_____	_____	_____
S1 Tall Shrub	_____	_____	_____
S2 Short Shrub	_____	_____	_____
S3 Dwarf Shrub	_____	_____	_____
H Herbaceous	_____	_____	_____
Grass	_____	_____	_____
Forb	_____	_____	_____
Fern	_____	_____	_____
N Non-vascular	_____	_____	_____
V Vine/Liana	_____	_____	_____
E Epiphyte	_____	_____	_____

Please see above table for height and cover classes

Animal Use Evidence:

Natural and Anthropogenic Disturbance Comments:

Other Comments:

Plot Code_____

Diagnostic Species

Stratum/Species	Cover	Stratum/Species	Cover

Cover: **01** **<1%** **04** **25-50%**
02 **1-5%** **05** **50-75%**
03 **5-25%** **06** **75-100%**

Plot Code_____

Diagnostic Species (Continued)

Stratum/Species	Cover	Stratum/Species	Cover

Cover: 01 <1% 04 25-50%
02 1-5% 05 50-75%
03 5-25% 06 75-100%

APPENDIX B

COMPARISON OF COWARDIN (1979) WETLAND CLASSIFICATIONS TO FGDC (1997) VEGETATION CLASSIFICATIONS

COMPARISON OF COWARDIN (1979) WETLAND CLASSIFICATIONS TO FGDC (1997) VEGETATION CLASSIFICATIONS

The following lists of PBS and Lewis Field formations identified during the survey are organized according to their corresponding Cowardin (1979) wetlands classifications for system (e.g., palustrine) and class (e.g., emergent). All wetlands at PBS and Lewis Field are believed to either palustrine or riverine systems. Note that formations do not distinguish position in the landscape as the Cowardin system does. Therefore, PBS and Lewis Field formations listed below may be either riverine or palustrine systems depending on proximity to river or stream systems. However, due to the lack of a large stream or river at PBS, most formations would be considered palustrine systems. No formations at PBS or Lewis Field are believed to be estuarine, marine, or lacustrine systems according to the Cowardin classification.

Note that neither system classification system is a reliable indicator of jurisdictional status. Accurate interpretations of jurisdictional status require a site-specific field delineation.

Palustrine or Riverine Aquatic Bed (PAB or RAB)

V.C.2.N.a. Permanently flooded temperate or subpolar hydromorphic rooted vegetation

Palustrine or Riverine Emergent (PEM or REM)

V.A.5.N.k. Seasonally flooded temperate or subpolar grassland
V.A.5.N.l. Semipermanently flooded temperate or subpolar grassland
V.B.2.N.c. Intermittently flooded temperate perennial forb vegetation

Palustrine or Riverine Scrub-Shrub (PSS or RSS)

III.B.2.N.c. Intermittently flooded cold-deciduous shrubland
III.B.2.N.f. Semipermanently flooded cold-deciduous shrubland
III.B.2.N.g. Saturated cold-deciduous shrubland

Palustrine or Riverine Forested (PFO or RFO)

I.B.2.N.d. Temporarily flooded cold-deciduous forest
I.B.2.N.e. Seasonally flooded cold-deciduous forest

APPENDIX C

LIST OF OHIO NATURAL ALLIANCES (TNC 1997)

LIST OF OHIO NATURAL ALLIANCES

I. FOREST

I.A.8.N.g. Saturated temperate or subpolar needle-leaved evergreen forest
Thuja occidentalis Saturated Forest Alliance
Tsuga canadensis Saturated Forest Alliance

I.B.2.N.a. Lowland or submontane cold-deciduous forest
Acer saccharum - *Quercus muehlenbergii* Forest Alliance
Fagus grandifolia - *Acer saccharum* - (*Liriodendron tulipifera*) Forest Alliance
Fagus grandifolia - *Quercus* spp. - *Acer* spp. Forest Alliance
Liriodendron tulipifera - *Tilia americana* var. *heterophylla* - *Aesculus flava* - *Acer saccharum* Forest Alliance
Quercus alba - (*Quercus rubra, Carya* spp.) Forest Alliance
Quercus prinus - (*Quercus coccinea, Quercus veluntina*) Forest Alliance
Quercus rubra - *Acer saccharum* - (*Quercus alba*) Forest Alliance
Quercus veluntina - *Quercus alba* Forest Alliance

I.B.2.N.d. Temporarily flooded cold-deciduous forest
Acer saccharinum Temporarily Flooded Forest Alliance
Betula nigra - (*Platanus occidentalis*) Temporarily Flooded Forest Alliance
Fraxinus pennsylvanica - *Ulmus americana* - *Celtis* (*occidentalis, laevigata*) Temporarily Flooded Forest Alliance
Salix nigra Temporarily Flooded Forest Alliance

I.B.2.N.e. Seasonally flooded cold-deciduous forest
Acer rubrum - *Fraxinus pennsylvanica* Seasonally Flooded Forest Alliance
Quercus palustris - (*Quercus bicolor*) Seasonally Flooded Forest Alliance

I.B.2.N.g. Saturated cold-deciduous forest
Larix laricina Saturated Forest Alliance

I.C.3.N.a. Mixed needle-leaved evergreen - cold-deciduous forest
Pinus echinata - *Quercus* (*alba, falcata, stellata, veluntina*) Forest Alliance
Pinus virginiana - *Quercus* (*coccinea, prinus*) Forest Alliance
Tsuga canadensis - *Betula alleghaniensis* Forest Alliance

I.C.3.N.d. Saturated mixed needle-leaved evergreen - cold-deciduous forest
Pinus strobus - (*Acer rubrum*) Saturated Forest Alliance

II. WOODLAND

II.A.4.N.b. Conical-crowned temperate or subpolar needle-leaved evergreen woodland
Thuja occidentalis Woodland Alliance

III. SHRUBLAND

III.B.2.N.d. Temporarily flooded cold-deciduous shrubland
Salix exigua Temporarily Flooded Shrubland Alliance

III.B.2.N.e. Seasonally flooded cold-deciduous shrubland
Alnus incana Seasonally Flooded Shrubland Alliance
Alnus serrulata Seasonally Flooded Shrubland Alliance
Cornus sericea - *Salix* spp. Seasonally Flooded Shrubland Alliance

III.B.2.N.f. Semipermanently flooded cold-deciduous shrubland
Cephalanthus occidentalis Semipermanently Flooded Shrubland Alliance

III.B.2.N.g. Saturated cold-deciduous shrubland
Cornus spp. - *Salix spp*. Saturated Shrubland Alliance
Vaccinium corymbosum Saturated Shrubland Alliance

IV. DWARF-SHRUBLAND

IV.A.1.N.g. Saturated needle-leaved or microphyllous evergreen dwarf-shrubland
Chamaedaphne calyculata Saturated Dwarf-shrubland Alliance
Vaccinium macrocarpon Saturated Dwarf-shrubland Alliance

V. HERBACEOUS VEGETATION

V.A.5.N.a. Tall sod temperate grassland
Andropogon gerardii - (*Calamagrostis canadensis*, *Panicum virgatum*) Herbaceous Alliance
Andropogon gerardii - (*Sorghastrum nutans*) Herbaceous Alliance
Schizachyrium scoparium - *Sorghastrum nutans* Herbaceous Alliance

V.A.5.N.c. Medium-tall sod temperate or subpolar grassland
Schizachyrium scoparium - (*Sporobolus cryptandrus*) Herbaceous Alliance

V.A.5.N.j. Temporarily flooded temperate or subpolar grassland
Andropogon gerardii - (*Sorghastrum nutans*) Temporarily Flooded Herbaceous Alliance
Spartina pectinata Temporarily Flooded Herbaceous Alliance

V.A.5.N.k. Seasonally flooded temperate or subpolar grassland

Carex lacustris Seasonally Flooded Herbaceous Alliance
Cladium mariscoides Seasonally Flooded Herbaceous Alliance
Phalaris arundinacea Seasonally Flooded Herbaceous Alliance
Scirpus fluviatilis Seasonally Flooded Herbaceous Alliance
Sporobolus heterolepis - Eleocharis compressa Seasonally Flooded Herbaceous Alliance
Typha spp. - (*Scirpus* spp. - *Juncus* spp.) Seasonally Flooded Herbaceous Alliance

V.A.5.N.l. Semipermanently flooded temperate or supolar grassland

Typha (*angustifolia, latifolia*) - (*Scirpus* spp.) Semipermanently Flooded Herbaceous Alliance

V.A.6.N.c. Tall temperate grassland with a sparse cold-deciduous tree layer

Populus deltoides Wooded Herbaceous Alliance
Quercus macrocarpa - (*Quercus alba*) Wooded Herbaceous Alliance
Quercus veluntina - (*Quercus ellipsoidalis*) Wooded Herbaceous Alliance

V.A.6.N.f. Medium-tall temperate or subpolar grassland with a sparse needle-leaved evergreen or mixed tree layer

Schizachyrium scoparium - Bouteloua curtipendula Evergreen or Mixed Wooded Herbaceous Alliance
Schizachyrium scoparium - Danthonia spp. Evergreeen or Mixed Wooded Herbaceous Alliance

V.A.6.N.g. Medium-tall temperate or subpolar grassland with a sparse cold-deciduous tree layer

Schizachyrium scoparium - Danthonia spp. Deciduous Wooded Herbaceous Alliance

V.A.7.N.p. Saturated temperate or subpolar grassland with a sparse cold-deciduous shrub layer

Pentaphylloides floribunda / *Carex* (*flava, interior, lasiocarpa, sterilis*) Saturated Shrub Herbaceous Alliance

V.B.2.N.d. Temporarily flooded temperate or subpolar perennial forb vegetation

Justicia americana Temporarily Flooded Herbaceous Alliance

V.B.2.N.f. Saturated temperate perennial forb vegetation

Symplocarpus foetidus - Caltha palustris Saturated Herbaceous Alliance

V.C.2.N.a. Permanently flooded temperate or subpolar hydromorphic rooted vegetation

Nuphar lutea - Nymphaea odorata Permanently Flooded Herbaceous Alliance
Potamogeton spp. *Ceratophyllum* spp. - *Elodea* spp. Permanently Flooded Herbaceous Alliance

APPENDIX D

PHOTOGRAPHS OF PBS AND LEWIS FIELD PLANT ALLIANCES AND COMMUNITIES

Photo 1. *Fagus grandifolia - Acer saccharum* - (*Liriodendron tulipifera*) Forest Alliance

Photo 2. *Quercus alba* - (*Quercus rubra*, *Carya* spp.) Forest Alliance

Photo 3. *Quercus rubra – Acer saccharum –* (*Quercus alba*) Forest Alliance

Photo 4. *Quercus veluntina – Quercus alba* Forest Alliance

Photo 5. Mixed (oak-dominated) cold-deciduous successional forest

Photo 6. Mesic, mixed cold-deciduous successional forest

Photo 7. Mixed-Deciduous successional forest

Photo 8. *Populus deltoides* successional forest

Photo 9. *Acer rubrum* - *Fraxinus pennsylvanica* Seasonally Flooded Forest Alliance

Photo 10. *Quercus palustris* - (*Quercus bicolor*) Seasonally Flooded Forest Alliance

Photo 11. Dry mid-successional cold-deciduous shrubland

Photo 12. Intermittently flooded late-successional cold-deciduous shrubland

Photo 13. *Cephalanthus occidentalis* Semipermanently Flooded Shrubland Alliance

Photo 14. *Cornus* spp. - *Salix* spp. Saturated Shrubland Alliance

Photo 15. Landscaped/Maintained grounds surrounding buildings

Photo 16. Maintained grassland

Photo 17. *Typha* spp. - (*Scirpus* spp. - *Juncus* spp.) Seasonally Flooded Herbaceous Alliance

Photo 18. *Phragmites australis* Seasonally Flooded Herbaceous Alliance (tall reeds in ditch)

Photo 19. Dry early successional herbaceous field

Photo 20. Intermittently flooded early successional herbaceous field

Photo 21. *Potamogeton* spp. - *Ceratophyllum* spp. - *Elodea* spp. Permanently Flooded Herbaceous Alliance

Photo 22. *Helianthus mollis* (ashy sunflower) population

Photo 23. *Tsuga canadensis* - *Betula alleghaniensis* Forest Alliance

Photo 24. *Fagus grandifolia* - *Acer saccharum* - (*Liriodendron tulipifera*) Forest Alliance

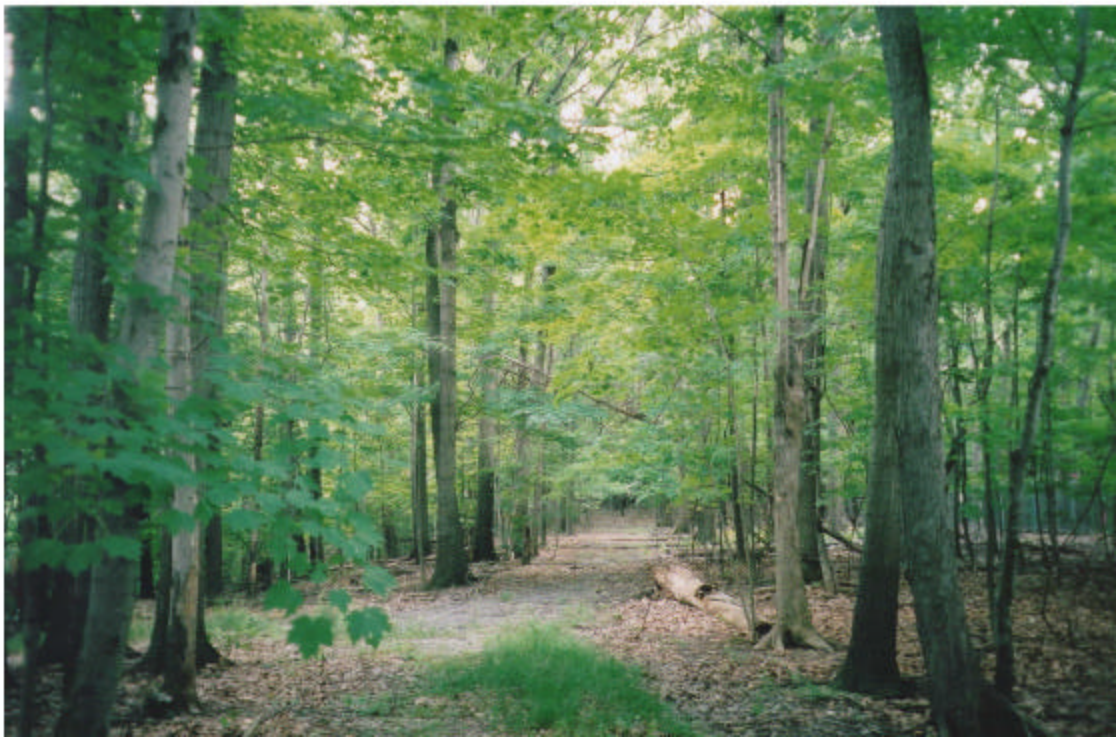


Photo 25. Quercus rubra – Acer saccharum – (Quercus alba) Forest Alliance

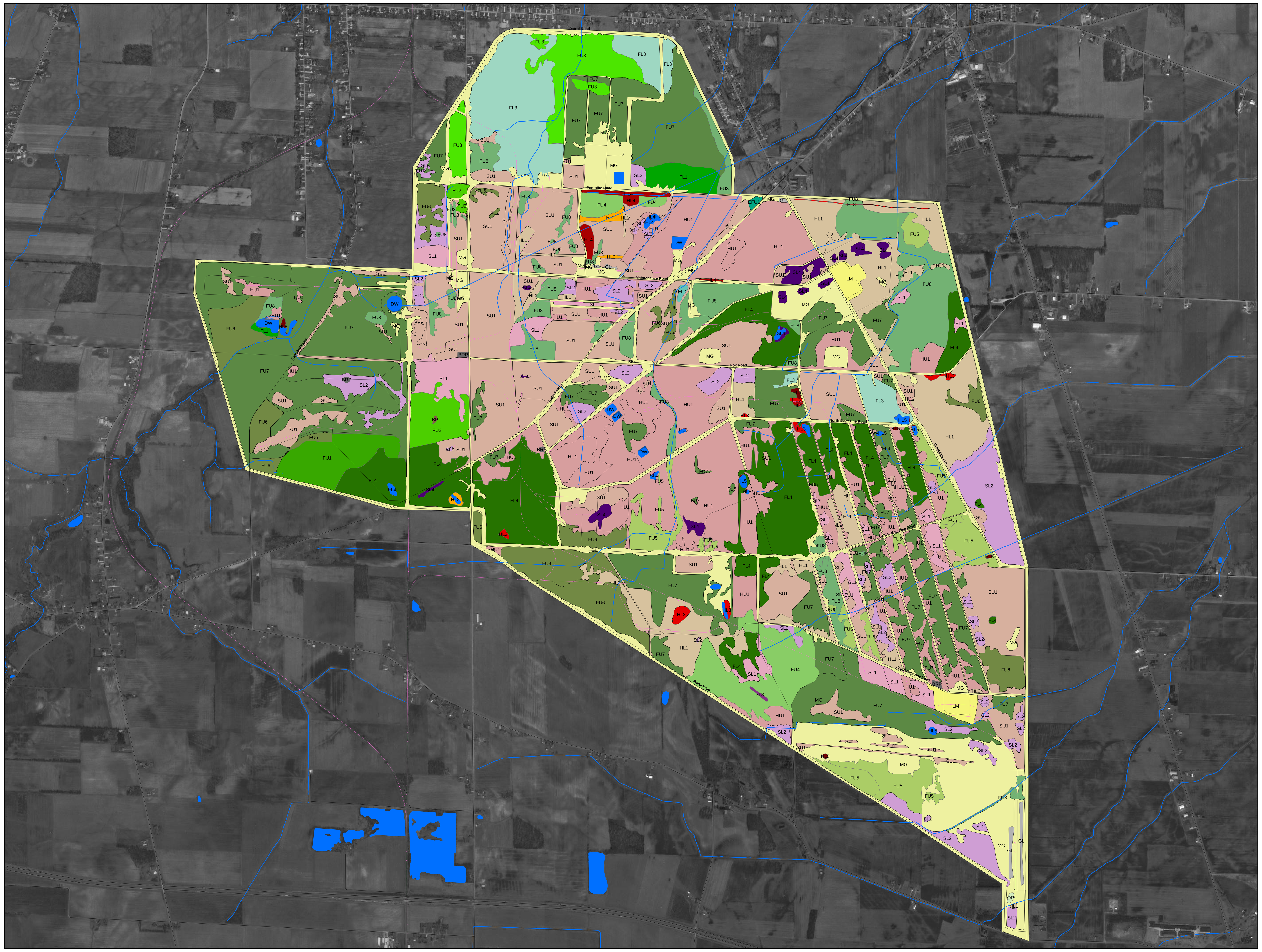
Photo 26. *Acer rubrum* - *Fraxinus pennsylvanica* Seasonally Flooded Forest Alliance (tree-line along drainageway)

Photo 27. Landscaped/Maintained grounds surrounding buildings

Photo 28. Maintained grassland (longer grass area)

Photo 29. Intermittently flooded early successional herbaceous field (herbaceous vegetation on either side of creek)

Plant Communities at Plum Brook Station



Forest Alliances \ Communities

- EFU1 Needle-leaved evergreen forest
- OR Orchard
- FU1 Fagus grandifolia - Acer saccharum - (Liriodendron tulipifera) Forest Alliance
- FU2 Quercus alba - (Quercus rubra, Carya spp.) Forest Alliance
- FU3 Quercus rubra - Acer saccharum - (Quercus alba) Forest Alliance
- FU4 Quercus velutina - Quercus alba Forest Alliance
- FU5 Mixed (oak-dominated) cold-deciduous successional forest
- FU6 Mesic, mixed cold-deciduous successional forest
- FU7 Mixed cold-deciduous successional forest
- FU8 Populus deltoides successional forest
- FL1 Fraxinus pennsylvanica - Ulmus americana - Celtis (occidentalis, laevigata) Temporarily Flooded Forest Alliance
- FL2 Salix nigra Temporarily Flooded Forest Alliance
- FL3 Acer rubrum - Fraxinus pennsylvanica Seasonally Flooded Forest Alliance
- FL4 Quercus palustris - (Quercus bicolor) Seasonally Flooded Forest Alliance

Shrubland Alliances / Communities

- SU1 Dry mid-successional cold-deciduous shrubland
- SL1 Intermittently flooded mid-successional cold-deciduous shrubland
- SL2 Intermittently flooded late-successional cold-deciduous shrubland
- SL3 Cephalanthus occidentalis Semipermanently Flooded Shrubland Alliance
- SL4 Cornus spp. - Salix spp. Saturated Shrubland Alliance

Herbaceous Alliances / Communities

- LM Landscaped/Maintained grounds
- MG Maintained grassland
- HU1 Dry early-successional herbaceous field
- HL1 Intermittently flooded early-successional herbaceous field
- HL2 Phalaris arundinacea Seasonally Flooded Herbaceous Alliance
- HL3 Typha spp. - (Scirpus spp. - Juncus spp.) Seasonally Flooded Herbaceous Alliance
- HL4 Phragmites australis Seasonally Flooded Herbaceous Alliance
- HL5 Potamogeton spp. Ceratophyllum spp. - Elodea spp. Permanently Flooded Herbaceous Alliance

Other

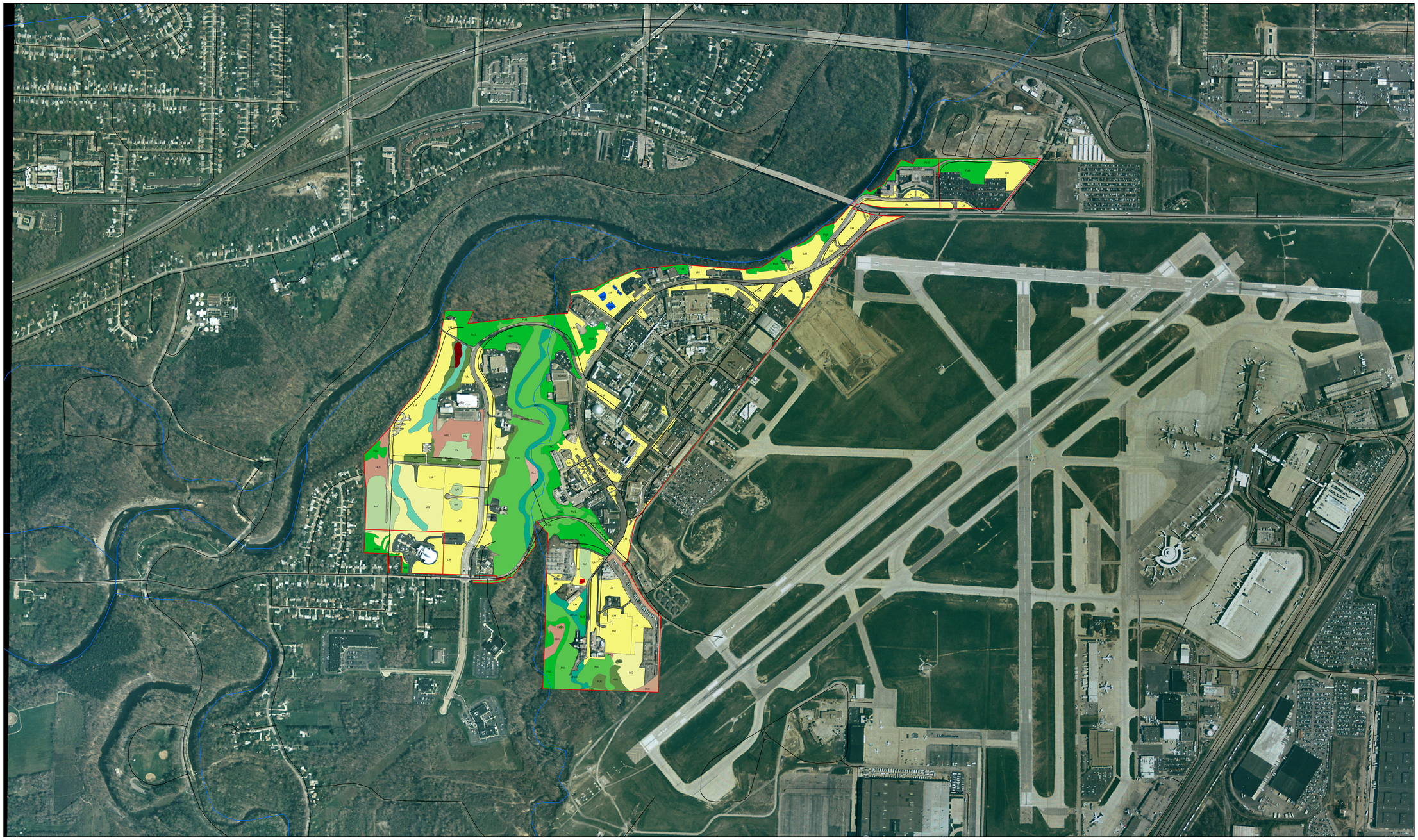
- Buildings, Roads, and Parking lots
- DW Deep water
- GL Gravel lot
- BP Borrow pit

N
W E
S

0 1,000 2,000

Feet

Plate 2. Plant Communities at Lewis Field



Forest Alliances / Communities

- EFU1 Needle-leaved evergreen forest
- MFU1 Tsuga canadensis - Betula alleghaniensis Forest Alliance
- FU1 Fagus grandifolia - Acer saccharum - (Liriodendron tulipifera) Forest Alliance
- FU3 Quercus rubra - Acer saccharum - (Quercus alba) Forest Alliance
- FU5 Mixed cold-deciduous successional forest
- FL3 Acer rubrum - Fraxinus pennsylvanica Seasonally Flooded Forest Alliance

Shrubland Alliances / Communities

- SU2 Dry late-successional cold-deciduous shrubland

Herbaceous Alliances / Communities

- LM Landscaped/Maintained grounds
- MG Maintained grassland
- HU1 Dry early-successional herbaceous field
- HL1 Intermittently flooded early-successional herbaceous field
- HL4 Typha (angustifolia, latifolia) - (Scirpus spp.) Semipermanently Flooded Herbaceous Alliance
- HL6 Potamogeton spp. Ceratophyllum spp. - Elodea spp. Permanently Flooded Herbaceous Alliance

Other

- Property Line
- Primary Roads
- DW Deep water
- BD/RD Buildings, Roads, and Parking lots
- NV Non-vegetated/Sparsely-vegetated disturbed area

N
W E
S

0 1,000 2,000

Feet